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Tuning Your Choral Pipes
An Organist's Manual for Choral Sound

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Abstract

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As choir masters, many organists have the responsibility of hiring and working with paid singers as well as a dedicated group of volunteer singers ranging in experience from novice to advanced. The similarities of the human voice to the pipe-organ are numerous. Using these similarities and scientific analysis of the two instruments, organists can familiarize themselves with the tuning system of the human voice.

Like the pipe organ, the human voice is capable of wide variety of sounds, qualities, textures, pitches and levels of volume. Unlike an organ pipe, the voice is not a fixed resonator. The voice is the most flexible of all musical instruments. Instructing an ensemble of singers to shape their sound simultaneously is the beginning of "tuning your choral pipes." It will be important to establish terminology with your singers in order to successfully communicate with them despite their varying levels of ability and pronunciation differences.

Becoming familiar with the mechanics of the voice and an alphabet of pure vowel sounds can help organist-choir masters achieve a greater degree of success when working with singers. The stops, pipes and expression pedal of the human voice are defined by the laryngeal muscles as they relate to registration, the vocal tract shape as defined by the vowel, and the amount of volume created by the air pressure.

This guide for organists covers these topics and contains exercises for the reader to apply during choral rehearsals.

Acknowledgements

There are a great number of people and musicians, both professional and volunteers, that have inspired the undertaking of this project. First, I would like to thank the late Dr. Gerre Hancock (1934-2012) and his wife Judith Hancock. Dr. Gerre Hancock was gracious enough to serve as my organ professor during my studies at Rice University. He spent his lifetime as organist-choirmaster championing the cause of sacred organ and choral literature in the United States. Dr. Hancock's enthusiasm and love for the role of the organ and choir in Church was infectious and motivated me to research current vocal, choral, and scientific trends.

My thesis advisor, Dr. Kurt Stallmann, has been a great support and offered valuable insight throughout the process of writing this organist-choirmaster manual. Many of the faculty and leadership of Rice University—Shepherd School of Music have shaped much of my appreciation, understanding, and performance of music. Dr. Robert Yekovich and Dr. Gary Smith made special arrangements and allowed me the privilege to study with Dr. Hancock.

Most of all I would like to thank my wife, Dr. Laura Avery, whose vocal expertise, patience, and understanding has helped me gain some applicable knowledge and tools to be a better organist-choirmaster. Laura has also allowed me to take advantage of her resources and network of colleagues in my research of this topic. Among her contacts are leading voice and choral scientists such as Dr. Johan Sundberg and Dr. Sten Ternström (KTH-Stockholm) who personally emailed me much of their recent research in the area of choral acoustics (published and unpublished).

I am also grateful for the long list of great organist-choirmasters that I have worked with in my personal studies, and even those whom I might not have officially met, yet whose music making has made such an impact on me that it sparked a desire to explore and further the tradition of the organist as choirmaster.

Table of Contents

Preface

The motivation behind writing *Tuning Your Choral Pipes—An Organist's Manual for Choral Sound* is an effort to address the lack of curricula and training of the musicians that are expected to lead and direct pre-dominantly amateur Church choirs.

At the age of seventeen I started my organist training with Dr. Ken Philips who serves as cantor (choirmaster) and organist in the Norwegian Lutheran Church. The organ pedagogy focused on accompanying hymns and sacred songs as well as organ literature.

My studies continued at Utah State University in Logan, Utah with Dr. James Drake. At USU, I would often accompany choirs, affording me the opportunity to collaborate with choral conductors. In some instances the organists at USU would serve as choral conductor. Though the training in organ studies and kinesthetic awareness (Alexander Technique) was formidable at Utah State, we never discussed choral methods in regards to vocal production in depth. The curriculum suggested that all organists take choral methods and private voice lessons as elective courses, but it was not a requirement to graduate.

My training continued as a MM student at Yale University. Yale has a program unlike any other in the United States in its collaboration between the Yale Divinity School and School of Music. Rigorous courses that prepare the organist as a Church musician have been strategically developed at the Yale Institute of Sacred Music and the Yale School of Music. As an organist at Yale, you choose your own classes from a pre-designed list specific for each semester. Leading scholars taught the courses at Yale, yet there was a lack of training in choral methods for organists. There were countless instances in our organ seminar courses where the topic of directing our church choirs arose. Techniques of conducting patterns from the console, evoking musical line and musicianship, periodic stylistic traits, and so on were all discussed. However, not one professor lectured on how we talk to the choir as a group of singers concerning the sound they are making and the ensemble they are creating.

While at Yale University I served as one of two organist choirmasters at St. Thomas Episcopal Church directing a semi-professional choir with several student singers from Yale University's School of Music and the famous collegiate men's chorus, *"Whiffenpoofs" of Yale*. It was a joy to make music with these singers. They were trained singers able to create beautiful ensemble. However, not very often (if at all) in my two years did my fellow organist friend or I discuss their vocal sound or suggest a different approach that would address intonation or their ensemble. Personally, I did not have the confidence to address a group of singers that knew more about the voice than I did. I found myself 'hiding' behind the organ and piano in our rehearsals. Uncomfortable and insecure with my inabilities to properly address the choir as an instrument, we simply sang through literature addressing musical interpretation but rarely did we make an attempt to address the intonation of the ensemble.

While pursuing my DMA at Rice University, I was fortunate to study organ with the late Dr. Gerre Hancock. Dr. Hancock was the much-celebrated organist-choirmaster at St. Thomas 5th Avenue in New York City for more than 30 years. During our time together we were able to discuss approaches to vocal production. It was evident that Dr. Hancock was very comfortable and passionate about the subject. He shared that his choral approach was rooted in what he learned as a student at Union Theological Seminary (NYC), and as a pupil of organist-choirmaster Dr. Robert Baker. Dr. Hancock explained that the training of organists at UTS focused equally on choir methods and vocal production. Two years of private voice and choir work was mandatory as part of the degree plan, and each organist was assigned to serve a NY/NJ Church as organist-choirmaster for two years.[1] Dr. Hancock acknowledged that there is a lack of focused curriculum for organists today with respect to choral responsibilities.

While pursuing my degree at Rice University, I was offered a position as coordinator of Sacred Music and Organ Studies for the School of Music at Sam Houston State University in Huntsville, TX. This was to be a new track of study with newly developed course offerings. In the effort to launch this program, a curriculum committee was formed to agree on appropriate course offerings. In the research phase of designing a curriculum, comparisons were made of many different Sacred and Church music programs throughout the United States and Europe. This examination further illustrated that singing was not addressed for organists, specifically working with choral singers. This finding was again confirmed when I attended Yale University's 15th National Conference on Organ & Sacred Music Pedagogy (2009), where several academic institutions graciously shared materials and outlines of their sacred music degrees. None of the degree plans shared involved compulsory vocal training. Moreover, while there was vocal music presented in performance at this conference, there were no workshops that addressed vocal production or how to work with singers.

My wife, Dr. Laura Avery is a trained soprano and vocal pedagogue. She has been a great collaborator and guide in developing my language for communicating sound production ideas to singers. This collaboration has led me to appreciate the large area of

[1] The School of Sacred Music at Union Theological Seminary was closed down due to lack of funding in 1973. A generous grant allowed Dr. Baker to found the Institute of Sacred Music at Yale University in 1973.

common ground shared by the pipe organ and voice organ. How many times have we heard the comment, “What a set of pipes,” given to an exceptional singer? The similarities of the human voice and the organ are numerous. It is possible to think of shaping the sound and blend of the choir, a collection of individual voices, in a similar way to playing an organ, a combination of individual pipes. Working with singers in our choirs, however, isn’t as simple as pulling stops and negotiating an expression pedal. Using the similarities of pipes and voices as common ground, however, one can familiarize oneself with singer terminology through the exploration of the tuning system of the human voice.

Though the pipe organ has been labeled the King of Instruments, it is important to note that there is no more complex instrument than the human voice. There exists a vast library of books devoted to the physiology and acoustics of the voice. While I will certainly cite relevant sources, the scope of this study will be limited to tuning the choir by encouraging the individuals in the ensemble to be aware of their personal contribution as it relates to the collective goal of a focused choral blend.

Choral conducting can be a complex activity combining theory with practice. It also merges historical perspectives with pedagogical, linguistic and literary insights. Organists often simultaneously combine these elements with the art of organ playing. This document is intended for organists who find themselves in this situation, and would like some effective suggestions on how to successfully tune their choir much like they tune the pipes of the organ.

Introduction

There are many similarities between the human voice and the organ pipes. The mechanisms with which the instruments sound are similar as well as the terminology used to describe them. Common terms to describe an organ pipe are: mouth, lips, teeth, organ, mixture, wind, body, breath, languid (larynx), resonator, neck, register, voix-humana, choir, pressure, open, closed, acoustic, voicing, speech, and the list goes on.

Indeed, the structure of the pipe-organ is patterned after the mechanics of the human voice. If, as an organist, you know how the pipe-organ functions, in turn you also know much about how the human voice functions. It is not just the pipe-organ whose design is modeled after the human voice. Like the voice, most instruments have three essential parts: an actuator, a vibrator, and a resonator. The function of the actuator is to provide power and energy to affect the vibrator. The vibration caused by the vibrator creates sound waves that can be audible if it resonates. The purpose of a resonator is to magnify these sound waves and acoustically alter the initial vibration to a desired musical sound.[2]

This document is divided into four chapters. Each chapter likens a function of the pipe organ to a vocal function. Chapter one, THE STOPS, is concerned with registration. Chapter two, THE PIPES, deals with vocal tract acoustics. Chapter three, THE EXPRESSION PEDAL focuses on dynamic control and variation. Chapter four, TUTTI, contains exercises and explanations offered as a guide to tuning, playing and enjoying your choral-organ.

What is the target sound of a well-blended choir, a well-tuned choral-organ? This document does not attempt to answer that question. This is simply a guide for those

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[2] McKinney, James. *The Diagnosis & Correction of Vocal Faults,* IL: Waveland Press, 2005, p. 25

organists seeking more information and understanding of the voice to enrich their choral experience and better the quality of their ensemble. We speak a common language, this document uses it to bridge the differences. During the course of preparing this document, these terms and their definitions have served as the benchmarks for successful choral ensemble as defined by the writer:

Color: A sound quality of a single voice that defines each section and the whole choir; however, no individual voices are identifiable.

Balance: Individual choral sections are dynamically balanced within the tonal texture.

Tuning: Pitch for voice leading is accurate, resolving points of tension clearly, and pitch is accurate and consistent among sections.

Diction: Vowels and consonants are pronounced uniformly and are intelligible by the listener.

Chapter I

THE STOPS
Registering the Choral-Organ

For organists, the term registration means the combination of different sounding pipes to create a certain color. Depending on the size of the pipe organ, seemingly unlimited combinations of pipes and sound colors are at our disposal. Pipes are divided into families of colors such as reeds, principals, strings, flutes, and hybrids. They might sound alike initially, but there are still differences within the label of each family.

All human voices have different qualities and colors. The voice literally comes in all shapes and sizes. The larynx (voice box), the oral cavity, nasal cavity, throat (pharynx), tongue, articulators, all affect the color and the tone of the speaking and singing voice. In the choir, and especially the amateur choir, combining these varying qualities in an ensemble blend can be challenging.

Voices are often classified into stereotypical Soprano, Alto, Tenor, Bass (SATB) categories of female and male voices with sub categories: lyric, profundo, mezzo, coloratura, dramatic. These characterizations are used to describe the timbre, quality, size and range of a voice. These labels are an attempt to objectify the many contrasting vocal qualities that singers possess. No two voices are alike and so it is not easy to describe nor classify the human voice.

The classification of the voice is most often done by range in the choral setting. The range in a singing voice is the number of notes, from the lowest to the highest pitch, a voice can sing comfortably. With vocal training, the functional range of a voice will expand. A singer's range will have a bearing on the solo or choral repertoire appropriate for the singer. It is however, only one of the determining factors in voice classification.

The register of the voice, the speaking range, the vocal timbre, the temperament, the intelligence, and the musicality of the singer, as well as the agility of the voice, are all of equal importance.

Unlike the pipe organ stop, we are generally not able to turn voices in our choirs off. The eloquent organist will change registration so subtly that the untrained ear is unable to detect adding or disengaging pipes. Given the fixed dynamic and resonance of the organ pipe these registration changes are manipulated to change dynamics from soft to loud and for dramatic effect. The voice works in a similar fashion; however, one must approach it in a slightly different way by knowing when to switch or isolate registers and manipulate volume at the same time as a group of singers. [3]

Commonly the registers (registration) of the voice are called chest voice, the middle or mixed voice, and head voice. The chest voice is made up of pitches that sound (resonate) below the general speaking range of a voice. The mixed voice includes those pitches said or sung in our regular range of speaking. The head voice range is made up of pitches that coincide with the pitches that ring above our speaking range.[4] Additional registers such as falsetto and whistle voice are respectively higher extensions of the male and female voice. There is much scientific research taking place regarding classification of the voice and registration.[5]

The break or passaggio of the voice is where the registration shifts for singers (see Figure 1). It is difficult for the hobby singer to know how to negotiate this area in the voice. Through explanation and direction from the choirmaster, proper proportions of

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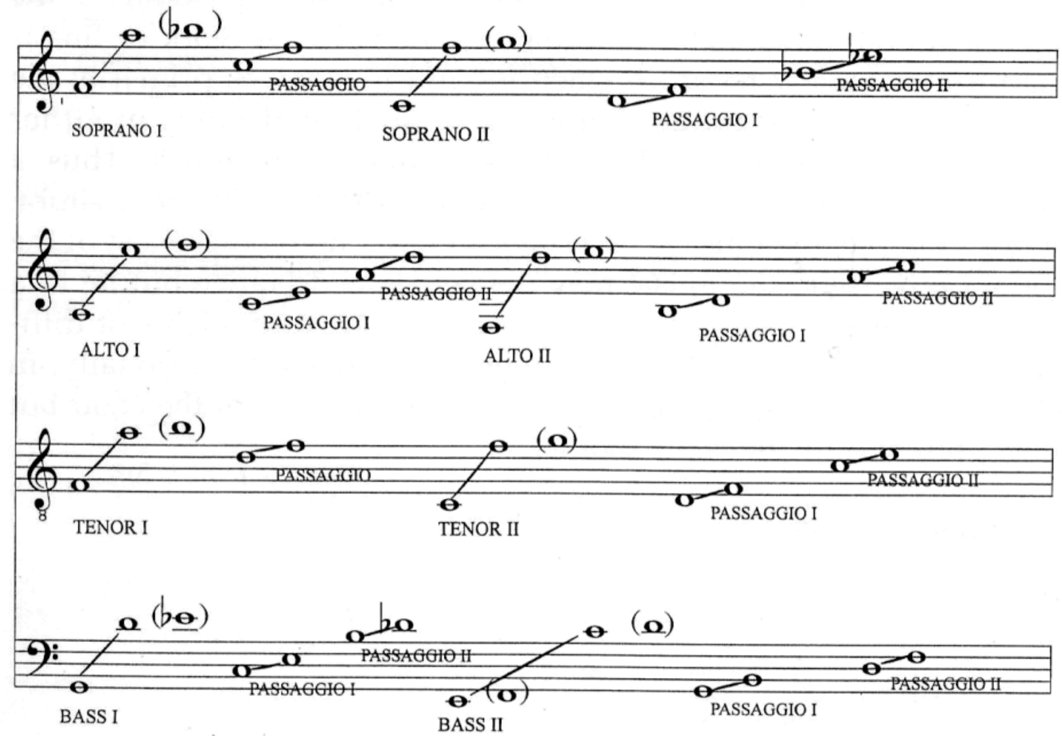
[3] Further elaboration on this is found in Ch.3
[4] Sataloff, Robert. *Choral Pedagogy,* Plural Publishing, 2006 p. 172
[5] Sundberg, Johan.. *The Science of the Singing Voice*. DeKalb: Northern Illinois University Press. 1987

energy, vowel, and dynamic, even the hobby singer can successfully learn how to sing through a registration shift.

Figure 1: Choral singing ranges[6]



As described above, a break is an unstable region of the range, lying between two registers of the voice. Because a vocal tone is a complex sound, combining breath, mental imagery, and muscle coordination, each pitch in the passaggio must be balanced in precise relation to the others. A voice “cracks” when muscle tension and breath management become imbalanced resulting in sudden, uncontrolled changes in a given note. This frequently occurs when a singer is shifting into a different register. It is particularly difficult for the hobby singer to determine and maintain the right ratios of breath, focus, dynamic control, and relaxation at these transition points. While “breaks”

[6] Sataloff, *Choral Pedagogy,* 176.

or "cracks" can occur at any point in a singer's range, they are more common at the points of registration shifting. Choirmasters should teach and encourage the choristers to sing in a unified ensemble, diminishing audible registration shifts.

Fach is the German word for compartment. In vocal terminology, the word Fach refers to the classification of the voice based on its timbre, temperament, agility and performance. The basic classifications are: soprano, mezzo-soprano, alto, tenor, baritone, and bass. There are also further qualifications within each *Fach.*[7] You will often find that trained singers will refer to themselves as a *Lyric tenor, Dramatic soprano,* or *Basso Profundo.* In a choir setting, these qualifications are obsolete. Singers attempting to maintain their fach qualities in a choral setting may fight the sound goals of a conductor.

There is a misconception among choral singers that singing second-soprano or second-tenor is somehow an assignment of secondary importance. These are divisi terms and should be viewed more as solo stops or a chorus of pipes on a pipe organ. Learning how to "register" your choristers' voices into well-selected sections allows for greater coloring and richness in your harmonic landscape. Voices are classified for choral singing by function with specific subsections of the choir: Soprano I, Soprano II, Alto I, Alto II, Tenor I, Tenor II, Bass I, Bass II. A voice classified for solo purposes as a soprano voice may function within a choir as an alto for sake of range, balance, or color for a brief period. It is the choirmaster's responsibility to classify voices for choral singing. When doing so, one should consider the following qualities: range, timbre, and musicianship.

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[7] John Warrack; Ewan West (1992). *The Oxford Dictionary of Opera*. USA: Oxford University Press.

The primary consideration should be the basic range of a voice. Refer to Figure 1 for the typical ranges for each classification and the points of passage between the registers. The section assigned should allow the singer to remain primarily in the most accessible and comfortable register(s) of the voice. Though a soprano and alto may have nearly the same range (highest and lowest notes), the alto may not be able to comfortably maintain the higher tessitura of the soprano line over an extended period of time. This is due in part to the difference in thickness between the two voices. The timbre or color of the voice is the initial identifying signal for classification. Think of it as a thin or thick organ pipe and the difference in tone it creates. A neo-baroque pipe organ has a differing (thinner) pipe density composite which produces a different signal compared to the 'thicker' harmonic development of the French Cavaille-Coll.[8] Conductors may combine the different vocal colors within the choir to create a particular quality within a given section of the choir. For example, if the repertoire to be sung is essentially that of the 19th century, sopranos possessing a 'warmer' quality might be used to build the Soprano II section for that piece. Those same voices might be asked to sing Alto I in a repertoire of the Baroque, where the fugal entrances require special coloration. Thus, timbre suggests balance as well as classification.

The musicianship of an amateur singer is a consideration in classification. If the singer sings fluently at sight, it is acceptable to assign a classification that will place the singer in extremes of range, rhythm, and pitch-especially if the singer is also skilled in vocal technique. A strong sensation for pitch, a cultivated aural image of timbre and tone, and a clear understanding of proper registration are aspects of an established vocal

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[8] Bicknell, Stephen. *The Cambridge Companion to the Organ, Organ Building Today*, Cambridge University Press, 1998, UK.

technique that will assist a voice in managing musical passages lying at the extremes of range. A trained soprano will know specifically how notes in the chest register should be sung, making an alto part possible. An alto with sufficient vocal technique can negotiate some soprano choral sections without applying excessive weight or color. If the singer is less proficient in basic musical skills, the voice should be protected from extreme demands. Hobby singer ambitions sometimes exceed technical or musical ability. Considerations of range, timbre, musicianship, and personal stability will guide the conductor to a wise choice.

What is a choral voice? A choral composer's mind and ear are guided by a sound ideal for each voice part; this is comparable to an opera composer's dramatic sense for each vocal role. The sound ideals have evolved through various historical style periods but have not moved far from the original point of departure. In the history of Western singing, the tenor voice was the first choral sound, deriving its name from the Italian verb tenere, meaning "to hold." Young men delivering the chants of the Church sang in unison. During the course toward maturity, some of the men developed lower voices. While the higher ones held the cantus firmus (the thematic material), the lower ones created supportive material below the melodic line. Those voices were called basso, meaning "low." As musical training grew in sophistication and prominence, younger boys were included in the choral activities of the early Church. These voices sang descant parts higher than the tenor and were referred to as alto, meaning "high." The highest voices, known as soprano meaning "above," were the last enrichments of the choral structure.

Centuries of choral music were built on a pyramid formation, with the bass as foundation, the tenor as chief color component, and the alto and soprano as ornamentation to the tenor line. The influence of operatic singing (particularly the popularity of the castrato) in the 18th century enhanced interest in the idiomatic capabilities of each vocal part, giving equal importance to soprano, alto, tenor, and bass in choral compositions. The growth and development of singing societies in the 19th century both divided and united the ranks of singers, creating strong, secular ensembles for men's voices (Männerchor) and large a cappella choirs emancipating women to sing the soprano and alto parts (Berliner Singakademie). Thus, choral classifications relate to choral roles within the repertoire, each singer offering elements of range, timbre, musicality, and spirit.

Choral sopranos in an amateur choir may be lyric voices, dramatic voices, or coloratura voices. Together, they carry primarily melodic or descant material. Choral sopranos are aware of their acoustic advantage over the rest of the ensemble. This exposure can be inhibiting and may cause some hobby sopranos to fear extremes of range and dynamics.

Hobby choral singers who prefer to sing alto are frequently soprano voices with a lack of ability or confidence in the upper range. Some are singers with a true devotion to singing harmony. The alto is often much like the foundations and purpose of the 8’ pipes of the organ. Since the range of the alto voice shares that of the foundational speaking voice, the alto section of a choir can assist the entire ensemble in delivering clear diction. Composed to accommodate harmonic needs, the material written for choral altos is often repetitive and uninteresting. This redundancy may result in a weakness of rhythmic accuracy and tuning. The choral alto is the courier of lyric text to the audience, an invaluable choral role that is critical to the color of the choir's output. For example, the addition of one "dark" contralto to an amateur ensemble can add years to the maturity of the choral sound.[9]

The limited quantity of true tenors is a fact of life. As the *Tierce en Taille* movement found in the French Classic Organ Suite, the majority of Renaissance choral repertoire was written to highlight the melody in the tenor line, thus in a high tessitura. Often the tenor section is few in number. As a result, this section in the choir can become vocally fatigued easily. The tenor section should be allowed to rest at regular intervals during a rehearsal session. Their vocal forces are fragile but mighty. If tenor voices are to be preserved, they must be protected. In most amateur choirs, the tenor section contains light, lyric baritones with easy access to the falsetto register. Occasionally, women's voices are used to balance the tenor part. Either remedy causes tuning complications. Acoustically, the brilliant timbre of the tenor voice dominates, cutting through the texture of the choral sound. Therefore, in terms of sheer numbers, it is possible to achieve a good balance with a smaller number of true tenors. It can be vocally unhealthy to substitute women or baritones for any extended length of time, and this practice should be permitted only under special circumstances with carefully selected voices. In the event that an ensemble is low on tenors, be aware that there are many settings of simple standard repertoires have been arranged for soprano, alto, and bass.

Choral basses are low voices, recognized for the richness and stability of their lowest notes. For this reason, choral basses seek to enhance the depth and weight of their

[9] Sataloff, *Choral Pedagogy,* 26.

sound. Lower voices tend to be less agile than higher ones, the bass being the least flexible of all due in large part to the thickness of their vocal folds. Like the pedal pipes on a large romantic organ, it is usual to find basses lagging behind the beat or pressing down upon the pitch. Notice in the warm up that descending patterns are more demanding to tune, hear or sing than ascending ones. Bass voices benefit from careful ear training and tuning exercises through vowel tuning, and from coloratura agility exercises.

Divisi within a choral section are a matter of taste and 'registration' of sounds available to the choirmaster—think of the choir as a choir-organ with a palette of sounds. A conductor may wish to divide choral sections based in performance practice traditions, by vocal expertise within a given section, by timbre of singers, or by equitable units. Each historical style period requires a choral sound with more or less vocal color within particular sections of the choir. Choirmasters must adjust the divisi of the choir according to the requirements of the music. Some conductors ask weaker readers to sing musical assignments that will strengthen their skill. Others may place stronger readers in harmonically challenging locations, allowing weaker readers to carry melodic material. Repertoire varies in breadth of timbre. Works based on a cantus firmus suggest a more diversified divisi, increasing the voices that carry the theme, while decreasing those singing subordinate material. Be aware that divisi can be used as means of achieving dynamic contrast. The addition or subtraction of voices, or the reassignment of some voices to other subsections of the choir, will adjust the dynamic level without challenging the skill of singers.

To achieve choral tone, a choir combines its corporate properties of voice, intellect, and musicianship, filtered and molded by the conductor. Like any singing sound, the choral tone is complex. Unlike solo singing, choral singing neutralizes the idiosyncrasies of individual singers to create a blend of voices. Choral tone is a cultivated sound, specific to each choir, and each conductor. In a letter to the Collegiate Chorale, February 12, 1953, Robert Shaw wrote:

> We've worked hard on musical disciplines. They aren't good enough. They never are-but all that we have accomplished is worth nothing at all unless it releases the spirit to sing and shout, to laugh and cry, or pray the primitive prayer. I earnestly believe, too, that the spirit-and only the spirit-can guide us to the sound. If hearts hymn, then the sound is illumined. If the inner necessity is large and compelling then the sound will be more than we need. People are only a little less movable than mountains, and the same thing moves them both.

Like carefully placed divisions of the pipe organ as developed in the baroque werk-prinzip of the North- German organ builders, the choral section is a unit made up of the individual properties of its singers. Like the division of pipes, singers are strategically placed in a space for desired sound and color. Although not scientifically proven, experience has shown that the placement of certain voices based on the compatibility of vocal color, frequency, and vowel production affects tuning and choral blend.[10] The organ and other instruments have a standard when tuning with a pitch designation of A4 at 438 - 442Hz. The human instrument, the voice, has an infinite number of pitches available to it, unlike the piano, which has only 88 at any given time. A singer has no frets (like a guitar) that point the way to the right notes.

Singing correct notes requires an accurate ear and controlled ear-voice coordination. Some singers tune readily with others, while some struggle mightily. When voices are placed close to one another, a battle of frequencies ensues. This can work to

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[10] Ternström, Sten. *Physical and Acoustic Factors that Interact with the Singer to Produce Choral Sound.* Journal of Voice 5, 1991.

the advantage or disadvantage of a choir. The next chapter will address this phenomenon in greater detail.

Chapter 2

THE PIPES
Tuning the Choral-Organ

Unlike an organ pipe, the voice pipe is not a fixed resonator. An organ pipe tunes simply by lengthening or shortening the resonator. Singers are trained to modify their vowels, thereby changing the shape of the resonating chamber. Just as an organ pipe is lengthened or shortened in order to tune it, so the human vocal tract, with the movement of the tongue, lips, soft palate and larynx, is lengthened and shortened to produce different vowel sounds. This modification to the resonating chamber will result in an alteration of the acoustic signal. The vocal tract, the singer's pipe, is a two-tubed system. Shapes created in the tubes, or pipes, are categorized as being open or closed shapes (vowels). If the front tube (oral cavity) is larger than the back tube (pharyngeal cavity), the vowel is labeled as "open." If the opposite relationship exists, then the vowel is considered "closed." Trained singers will know how to modify their vowels, thereby changing the shape of their resonating chambers. This modification to the vocal tract will result in an alteration of the acoustic signal. Each vowel sound registers its own acoustic signature. Most church choir members are not trained singers. Teaching your choristers to modify their vowels, thereby changing the shape of the resonating chamber, while retaining the integrity of the acoustic signal is the beginning of tuning your choral pipes.

The voicing and tuning of an organ is a very similar process to that of voicing and tuning an ensemble of singers. Voicing the organ is completed in a variety of ways but much attention is given to unifying the mouth and teeth of all the pipes in a rank so that the end result is good ensemble. Using familiar organ terminology, we could say that each singer in a choral ensemble acts as a pipe and each section, a rank of pipes. The common denominator that links your choral pipes is the vowel shape. As with the organ pipe, if the choir modifies the voicing of their sound and agrees on a vowel, pitch and dynamics, they will create cohesive ensemble. Releasing or closing the jaw, rounding or spreading the lips, raising or lowering the larynx, or lifting or dropping the soft palate will all change the shape and therefore resonating frequencies of your choral pipes. Vowel accuracy and agreement are important factors in blending your singers. The influence of these factors should not be underestimated. Experimenting with any of the above mentioned vowel articulators will result in significant changes to the tone due to vowel acoustics. For example, if a vowel sounds too bright, rounding the lips when singing the vowel will lower the second formant.[11] If in turn a back vowel seems too dark, making the lips less round while singing the vowel will raise its second formant.

Sometimes choirmasters instruct their singers to use one mouth and tongue shape for all vowels. Regarding such a method, world-renowned vocal pedagogue Richard Miller states: “pernicious is the technique of distorting all the vowels throughout the range by assuming some one ideal mouth and pharynx posture through which all vowels must then be produced.”[12] This is not a productive method.

So why should choirmasters bother with changing their choristers’ vowels? Vocal pedagogue Oren Brown answers, “It is impossible to maintain one vowel position at all pitches. Vowel modification must be mastered to facilitate a smooth transition from low to high and soft to loud. . . . As a basic rule, the louder or higher, softer or lower a vowel is sung, the more it will migrate.” The vocal tract has the ability to change to match pitch

[11] A brief definition of formant is found on page 18.
[12] Miller, Richard. Diction and Vocal Technique, NATS Bulletin, January/February 1982, p. 43.

and also frequency of vowel and energy of sound. It should not be assumed by the choirmaster that singers whether trained or hobby singers are aware of these tuning mechanisms.

There seems to be some controversy amongst choral directors and teachers of singing regarding vowel modification. While singers can sing most notes on almost any given vowel, there are certainly acoustical and physical roadblocks that will cramp the sound and style of the voice. Noted vocal authority Berton Coffin explains: When the vowels have achieved their best position, breath-coordination problems diminish. Freedom of function in one part of the vocal instrument induces freedom in others. Vowel modification brings the frequencies of the vocal cords and the vocal tract into concord on the various notes and vowels. "As a trumpet player must learn to vary the length of his tubing by use of fingering the valves on that instrument, or the trombone by the use of the slide, for best tonal results the singer must be able to vary the effective length of his instrument by the use of various vowel colors. These are formations of the vocal tract caused by movements of the lips, tongue, depressor and/or elevator muscles of the larynx, and action of the soft palate."[13]

Voice scientist Johan Sundberg, a leading authority on presenting this complicated subject in musician terms, explains that the vocal tract resonator has different requirements for the sounds that try to pass through it, depending upon the frequency of that sound. Certain frequencies pass through the resonator easily and, as a consequence, are given high amplitude. They are called resonant frequencies. In the vocal tract these resonances are called formants. The formants determine vowel quality and

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[13] Coffin, Berton. *Coffin's Sounds of Singing: Principles and Applications of Vocal Techniques with Chromatic Vowel Chart.* 2nd ed. Metuchen, NJ: The Scarecrow Press, 1987.

timbre to the voice. Vowels are identified by the relationship of two formants, F1 and F2, which are related to tongue position and degree of lip-rounding.[14] Formants are identified by their frequencies, measured in Hz. The presence of these two frequencies, whether produced by a person, a bird, or a computer, results in the perception of that vowel by the listener. The formant frequencies are independent of the pitch being produced by the vibrating vocal folds. A sung or spoken vowel thus consists of the complex sound contributed by the vocal folds, plus the supraglottal resonances which result from the particular vocal tract shape required to form that vowel. How the glottal sound source and the vowel formants interact will be discussed below.

Berton Coffin proposed the following experiment to hear the relative frequencies of each formant: To hear F1, form the vowels [i, e, a, o, u] while using a finger to thump the base of the tongue under the jaw, with open mouth and closed glottis (permitting no air to pass through). The pitch heard will rise and fall as the vowels are changed. To hear F2, whisper the same vowels. A steadily descending pitch can be heard.[16] Typical formant frequencies of the five cardinal vowels are given in Table 1. Because of the difference in size of the vocal tract in men and women, formant frequencies in women's voices are roughly ten to fifteen percent higher.[17]

[14] *Vocal tract resonance can include as many as five formants, but only the first two identify the vowel.*

[16] *Coffin, Berton. The Singer's Diction,* The NATS Journal 20, no. 3 (January/February 1964): 10.
[17] John Howie and Pierre Delattre, *An Experimental Study of the Effect of Pitch on the Intelligibility of Vowels, in Contributions of Voice Research to Singing,* ed. John Large (Houston, TX: College-Hill Press, 1980), 388.

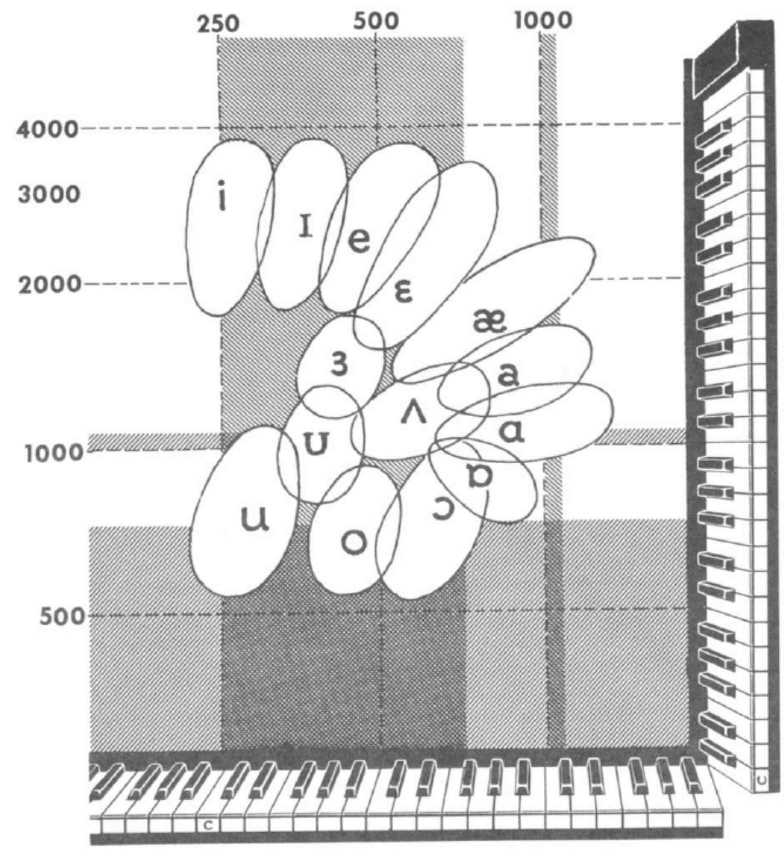
Table 1: Formant frequencies of the cardinal vowels.[18]

Vowel	F1	F2
[i]	men: 270 Hz (C#4) women: 310 Hz (D#4)	men: 2,290 Hz (C#7) women: 2,790 Hz (F7)
[ɛ]	men: 530 Hz (C5) women: 610 Hz (D#5)	men: 1,840 Hz (A#6) women: 2,330 Hz (D7)
[ɑ]	men: 730 Hz (F#5) women: 850 Hz (G#5)	men: 1,090 Hz (C6) women: 1,200 Hz (D6)
[o]	men: 570 Hz (D5) women: 590 Hz (D5)	men: 840 Hz (G#5) women: 920 Hz (A#5)
[u]	men: 300 Hz (D4) women: 370 Hz (F#4)	men: 870 Hz (A5) women: 950 Hz (A#5)

These frequencies are only approximations or averages, since every human vocal tract possesses slightly different dimensions. Another way to view the formants is as a range of possible values for each formant, accounting for variances among individuals. When graphed, this range of values creates an area such as a circle or oval, rather than a single point. Vennard's chart, given in Figure 2, shows such a graph. The first formant frequencies are shown on the horizontal axis, and the second formant frequencies are shown on the vertical axis. The [i] vowel, for example, is shown to have a range of possible first formant frequencies from roughly 200 to 350 Hz, and a range of possible second formant frequencies from roughly 1900 to nearly 4000 Hz. For reference, Vennard also plots these frequency ranges against a piano keyboard, with C4 denoted by the letter C on the key.

[18] McCoy, Scott. *Your Voice: An Inside View*. Princeton: Inside View Press, 2004. 44-45.

Figure 2: Average formant frequencies of English vowels.[19]



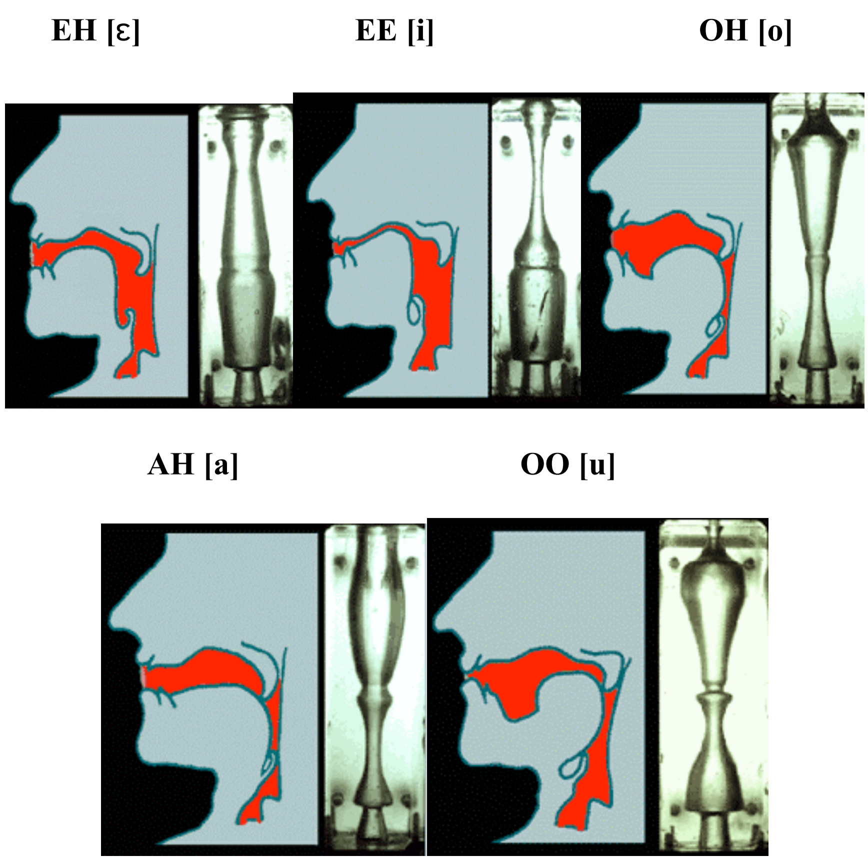
Vowel color is determined by the two lowest formants; timbre is determined by the third, fourth, and fifth formants. Tuning the formant frequencies is done by changing the shape of the vocal tract: the jaw, the tongue, the lip opening, the larynx, and the side walls of the pharynx.[20] Adjusting the shape of the vocal tract through vowels is the most common method for tuning the formant frequencies.

As with an organ pipe, the singer's pipe, the vocal tract, can be lengthened and shortened by adjusting the shape of the resonating cavities or chambers: the pharyngeal and oral cavities specifically. Remember that the voice is not a fixed resonator like an

[19] Vennard, William. *Singing: The Mechanism and the Technic*,
rev. ed. (New York: Carl Fischer, 1967), 137.
[20] Sundberg, Johan.. *The Science of the Singing Voice*. DeKalb: Northern Illinois University Press. 1987

organ pipe. Singers can be trained to modify their vowels, thereby changing the shape of the resonating chambers. The vocal tract is a two-tube tuning system not unlike a hunter's duck call. This is illustrated in Figure 3 below.[22] The singer's vocal tract, producing five distinct vowel sounds, is coupled with a duck call similarly shaped, which when blown, will produce the same vowel sound as the human vocal tract.

Figure 3

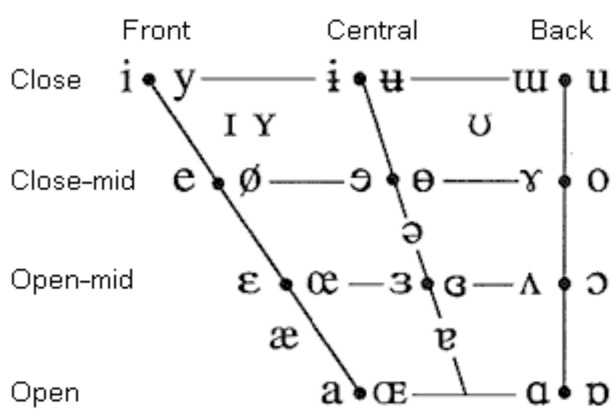


[22] The Musum of Science, Art and Human Perception. *Vocal Vowels,* <http://exploratorium.edu/exhibits/vocal_vowels/> March 2012.

Open and closed vowels are categorized based on the two-tube system model illustrated above. If the front tube (oral cavity) is larger than the back tube (pharyngeal cavity), the vowel is labeled as "open." If the opposite relationship exists, then the vowel is considered "closed." It's interesting to note that many trained singer's are encouraged to open both the pharyngeal and oral cavities, especially in a higher range, thereby distorting vowel clarity and modifying the acoustic signal away from anything useful if the goal is a unified choral sound.

Knowing which vowels to use for tuning is invaluable for choral directors. More important still is successfully communicating those vowels to a group of people with regional accent variations and pronunciation differences. Familiarizing yourself with an alphabet of pure vowel sounds and teaching your choir those symbols can expedite your tuning results. Techniques for sharing this information with your choirs will be included in Chapter 3. In Figure 4 is a vowel chart utilizing symbols from the International Phonetic Alphabet (IPA) illustrating the variants of open and closed vowels.

Figure 4



To further illustrate, take for example the “aw” vowel used in word wall or law, the IPA symbol for that sound is [ɔ]. The symbol for the “ah” sound used in the word yacht is [a]. Asking your choir to modify from [ɔ] to [a] as they increase in volume will allow for better control of the pitch center. Other vowel modifications that will take singers from an open sound to a closed sound are, [ɛ] as in bed to [e] as in pain or whey without the diphthong; [ɪ] as in sit to [i] as in see; [ɔ] as in law can either be modified to the [ɑ] in father or the [a] in yacht depending on vocal range (the higher the range, the brighter or more forward the vowel).

Given this comparison, it would seem that the main difference between organ and choir is text. The choir is communicating words that should be readily understood by the listener. Agreeing on the vowel will unify the text as it is delivered to the listener making the text easier to discern for the listener. If vowels are not unified, the opposite may occur, compromising the clarity of the sound and burying the text under a wall of sound.

Attention should be given to vowel “placement” in the resonators when communicating directives to a group of singers. Choristers should play with sound and be receptive to vowel modification. Improving the quality of tone and timbre through intentional vowel choices will go a long way in creating blend. Hearing the result of this focused work will instill confidence and acceptance of the work by your choristers. Expose your choir to the IPA symbols of the most common vowels. This will ensure precision in vowel tuning. Encourage your choristers to use the vowel IPA symbols in their scores to unify pronunciation.

Like carefully choosing an ensemble of pipes in your Bach fugue registration; a choral tone is a sound uniting or "blending" all participatory voices. It is the color, quality, and quantity of sound indicative of a particular set of choral forces—the choir-organ and their organist. The choirmaster selects for and against certain tendencies in the individual voices of the assembled singers. Through deliberate repetition, the end result of the choirmaster's gentle admonition and guidance is imprinted in the memory of the choir. When speaking of the blend of the sound as the identifying tone, the choral fingerprint of the ensemble, Lloyd Pfautsch stated:

> The sounds of his chorus will be a commentary on his ability to transfer his knowledge, to enlarge and refine his pedagogical techniques, to arouse and maintain dedication to vocal and musical disciplines on the part of the singers, to shape the syllabic and melodic nuances, to expand the knowledge and technical proficiency of the chorus, and to lead the group to artistic performance.[23]

The singing voice is complex with aspects of a fundamental frequency ($f0$) surrounded by its overtones. Like the sound color of your fundamental pipe (8' flute or principal), the vocal timbre may be thought of as the fundamental aspect of the tone. The organist deliberately chooses the quick speaking pipes with clarity when interpreting textures that demand polyphony. The heavier and often slower speaking pipes are warmer in color and are often appropriate for romantic textures that favor melody and homophony. Similarly, you'll have choral pipes with a "darker," "heavier," "dramatic" in tonal quality and others that are "lighter," "brighter," more "lyric." These two pipes may speak differently but they behave in the same way.

Choosing open or closed vowels allows a choirmaster to color the choral-organ to suit varying musical genre and styles. It is likely second nature for an organist-choirmaster, given their understanding of various colors and pipe combinations, to invite this sort of exploration of sound and colors with their ensemble of choristers. For

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[23] Pfautsch, Lloyd. *The conductor and the rehearsal.* In*:* Decker H, Herford J, eds.*Choral Conducting: A Symposium*. Englewood Cliffs, NJ: Prentice-Hall Inc;
1973:78.

example, instructing the ensemble to sing closed, bright vowels with the soft palate lowered should generate a child like quality with little warmth and minimal vibrato. If the choirmaster desires a sound that resembles the English Cathedral tradition of men and boy choirs this might be a great place to spend time in rehearsal with the sopranos and altos, focusing the sound of their treble pipe resonance. Often, even hobby singers have received a little voice training, and have been instructed to approach vocal production with a raised soft-palate and open pharyngeal space. A lowered larynx and open resonance is what is typically taught by voice teacher training in the classical style. However, depending on the literature, this approach to sound creation is not always ideal for an ensemble of singers. The varied shapes of the resonating vowels distorts the sound, creating dissonance in the ensemble. [24]

Bel canto, the Italian school of singing, advocates a balance between open and closed vowels. Chiaroscuro is the art of retaining the best qualities of both open and closed vowels in the voice at all times. In this tradition, certain vowels are considered chiaro, or bright, and others are oscuro, or dark. Their blending creates an even proportion of the two. The model of chiaroscuro can be used to balance the choral tone and tune the vowels.[25] The color quality of a vowel (bright to dark) has been found to influence pitch accuracy. Brighter vowels, resonating more forward in the vocal tract such as /a/ and /i/, have less intonation errors than darker vowels resonating further back in the vocal tract like /u/ and /ɔ/.

The shape of the vowel, whether closed, open, or a balance of both (chiaroscuro),

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[24] Ternström, Sten. *Physical and Acoustic Factors that Interact with the Singer to Produce Choral Sound,* Journal of Voice 5, 2 (1991)
[25] See Chapter 4 for exercises that can aid in the application of chiaroscuro.

is a crucial element when tuning fundamental frequency ($f0$). Johan Sundberg and Sten Ternström have explored this idea in several scientific studies. The task was to allow a choir to sing a normal eight chord warm-up cadence in their normal rehearsal room until the conductor believed the choir had achieved good intonation (five times). The $f0$ of each bass (N = 6) was measured and compared to the target pitches. The standard deviation of all 192 pitches was 13 cent (range 3 to 24 cent). The standard deviation of all participants' 23 tones ranged from 3 to 30 cents. The greatest deviations occurred when the reference tones were different in vowel – not in pitch, which suggests vowel properties influence the scatter of $f0$.[26]

How does modifying vowels affect their spectra? Bloothooft, physicist and phonetician, in three landmark studies considered the effect of $f0$, mode of singing, and voice classification on the vowel spectra. Participants (N = 7 male and 7 female singers) were recorded on a microphone (0.3 centimeters from the singers' mouths) singing nine vowels on five voice classification specific pitches in different modes of production (neutral, light, dark, free, pressed, soft, loud, straight [without vibrato], and extra vibrato) for a duration of 1-2 seconds. His findings overall were that mode of singing had very little effect on the spectral variance in all voice classifications. Spectral variation was effected the most by vowel production.[27] [28] [29]

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[26] Ternström, S., Sundberg, J.. *Acoustical factors related to pitch precision in choir singing.* Speech Transmission Lab. Qt. Prog. Status Rep. 2-3, 76-90 (Dept. of Speech Communication and Music Acoustics, Royal Institute of Technology, Stockholm), 1982.

[27] Bloothooft, G., Plomp, R. *Spectral analysis of sung vowels: I. variation due to differences between vowels, singers, and modes of singing*. Journal of the Acoustical Society of America, 75, 1984.

No vocal function lives in isolation. One cannot separate registration from vowels as the two influence and impact each other. It is through mastering the coordination of both that one is able to truly command the voice in the creation of its many textures and timbres. Woven into this intricate art of choral sound is expression. The next chapter will deal with how to maneuver the expression pedal of your choir. We will see that vowel selection plays an important role in dynamic expression and that volume dictates registration selection.

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[28] The same participant data was used for the second evaluation in which the effect of the $f0$ on vowel spectra with respect to the factor vowels. Factor vowels are the single most important source of spectra variance for low fundamental frequency ($f0$). Male and female variants were consistent with one another. The relationship between the average sound level of the singer's formant and the $f0$ was found to be vowel dependant. Higher fundamental frequency ($f0 = 392$ Hz) resulted in a lower singer's formant in women. Modal register had less variability in the first formant than the falsetto register and it was hypothesized that this is because in higher singing the first formant is very close to the $f0$. Bloothooft references Sundberg (1981) *"strong acoustic coupling between glottis and vocal tract"* as a possible cause.
Sundberg, J. *Formants and fundamental frequency control in singing: an experimental study of coupling between vocal tract and voice source*. Acustica, 49 , 1981.
Bloothooft, G., Plomp, R. *Spectral analysis of sung vowels II. The effect of fundamental frequency on vowel spectra*. Journal of the Acoustical Society of America, 77 (4), 1985.

[29] See Appendix A for further studies on vowel and formant modification and tuning conducted by current leading scientists.

Chapter 3

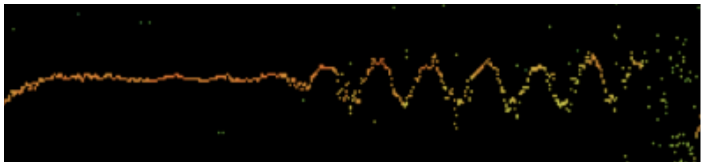
THE EXPRESSION PEDAL
Nuancing the Choral-Organ

Using the expression pedal on the organ does not increase the instrument's chances of going out of tune. The same cannot be said of singers. Simply put, choral directors have to master using the expression pedal while tuning the pipes of their singers. It is a well-known fact amongst organists and organ pedagogues that one should avoid using undulating Celeste pipes and tremolo effect when accompanying a body of singers because it creates unnecessary departure from the fundamental pitch ($f0$). In singing, the natural undulation of tonal frequency within the parameters of the pitch, having no greater variation than about a semitone, is defined by Sataloff as vibrato. Vibrato is a vital element in vocal tone and tuning. It is a major consideration in choral blend. Vibrato is made regular and steady through practice. Vibrato to a singer can be likened to engaging tremolo on the pipe organ. The tremolo stop on the organ will disturb the wind supply through the pipe creating a waver of the pitch. Similarly, the human voice wavers naturally under the pressure of air. Definitions of these terms vary from instrument to instrument. To be clear, Sataloff explains that tremolo in the singing voice is an excessive, wide vibrato. Tremolo as defined by Sataloff should not be confused with the tremolo stop on the organ which is used to emulate the natural vibrato of the human voice. Figure 5[30] is a spectrograph plot of a voice moving from minimal vibrato to

[30] Breen, Edward. University of York, Department of Music, Heslington, York, UK 2012.

more active vibrato. The horizontal line in the graph represents duration of time and the vertical line represents frequency.

Figure 5



One can easily observe that as the vibrato develops and becomes more intense, the changes in frequency are subject to wider peaks. This is a visual reflection of the aural fluctuation away from a pitch center. Vibrato is expected to be present in certain genres such as opera and art song, is used ornamentally in other styles like jazz and folk song, is used for dramatic effect in musical theatre and is typically minimized in choral music. Vibrato is an artistic choice that can be musically justified if the intensity of the piece calls for it. If singers are not conscious of their vibrato pattern and use their vibrato without restraint and skilled control, the pitch variation can become too great and breath pressure too intense. Excessive, intense breath pressure can lead to a wobbling vibrato or a fluttering tremolo. Vibrato can also be diminished in a healthy manner with simple exercises rooted in flow phonation. This will be discussed further discussed in Chapter 4. Note: The age and size of a voice and the overall physical condition of a singer may cause unappealing rates of pitch variations their use of vibrato.

Excessive vibrato is more often associated with an increase in volume rather than a deliberate choice of expression. When working to blend the sound of a group of singers, caution them about using too much breath pressure or volume. A common approach to teaching solo singers is to have them coordinate a more open pharyngeal space with greater breath pressure. The resulting sound is typically a wide vibratory pattern. Combining volume control with vocal tract shape (the vowel) will enable a singer to retain better pitch clarity. Instructing a body of singers to modify dynamics simultaneously in this fashion is another component of tuning your choral pipes.

Keep in mind while tuning your choral-organ that singers have a tendency to get louder as pitch ascends and may open their resonators through register shifts. By increasing the air pressure to gain a louder sound, the fundamental frequency is raised, a phenomenon that singers must learn to compensate for.[32] More importantly the organist-choirmaster must be aware of the problem caused by "over blowing" your pipes. Just as the organ pipe will loose its fundamental pitch through over winding, the same tendency can negatively impact the ensemble's tuning. Choirmasters can prevent this from occurring by encouraging singers to control their volume through their mid-range as they shift into head voice muscle function (cricothyroid) and resonance. Instruct your choir to utilize brighter, closed vowels at a lower volume as they negotiate mid-range to high-range singing.

We've seen that air pressure affects organs and singers differently and that the vocal pipe, unlike an organ pipe, is not a fixed instrument. Utilizing these two principles, organists working with choral singers can master tuning their choral pipes with ease and joy, finding as much expression and color within their ensemble as can be found within organ registration.

In the choral setting, the acoustic landscape is complex with many individual voices attempting to create a unified sound. A strong voice in the choir immediately has an effect on weaker singers. That individual's voice, however, may not always be the

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[32] Sataloff, *Choral Pedagogy,* 25-27.

vocal quality desired by the choirmaster. Ingo Titze raises awareness concerning the choral environment's influence on vocal production:

> It's hard to determine how to balance your loudness with someone standing right next to you. You're getting your own sound from the side, you don't know what sound is going straight from your mouth. And so you have to balance your loudness to persons on either side of you based on what you hear laterally. Sometimes what you get from one ear is different from what you get from the other ear, and the quality is different and the vowels are different…The whole idea of loudness and pitch is greatly affected by whether you make your vowels the same.[33]

When you close the organ swell shades it causes an immediate acoustic reaction to the sound of the pipes. Though it would be awkward to box a choir in a swell chamber, the collective effort choir singers make with their volume control must respond in much the same way as the organ swell shades. Allen Goodwin sites in his study of choral acoustics that individual singers must match the output of other choristers, which will result in acoustic modification:

> It is a common observation that singers attempting to blend reduce their dynamic level to avoid being conspicuously loud in the ensemble. The results of this study suggest that choral singers may adjust their overall intensity not only to affect the perceived loudness of their tones, but also to create other acoustical changes in their vocal sounds, which singers perceive as helpful for achieving vocal blend...Reducing the overall intensity also has shown to produce complementary changes in vowel clarity and vocal registration, particularly when detrimental qualities are associated with over-singing. [34]

Scientific studies show that the best way to tune choral ensembles is through dynamic control and vowel modification, as was discussed in Chapter 2. Moreover, a well-blended choir is one that is also able to maintain a unified timbre when changing dynamics and vowels. Richard Miller labels this as "resonance balancing."[35] The balance comes from the volume control and the resonance comes from the vowel. As previously explained, vowels formed with a high, forward tongue, such as [i], [I], and [e], have high

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[33] Titze, Ingo. *The Solo Singer in the Choral Setting—Interview with Margaret Olson* (2000)*,* Scarecrow Press, 2010.
[34] Goodwin, Allen W. *An Acoustical Study of Individual Voices in Choral Blend.* Journal of Research in Singing and Applied Vocal Pedagogy 23, 1989, 25-34.
[35] Miller, Richard. *Solutions for Singers: Tool for Performers and Teachers*, New York: Oxford University Press, 2004, 78.

second formants. Like the resonance of a closed gedeckt organ pipe, these second formants can amplify upper harmonics in the sung sound reducing the need to add vibrato in order to increase volume. Vowels formed with the high point of the tongue farther back in the mouth, such as [u], [a], and [o], have lower second formants and therefore do not amplify as easily increasing the impulse to add vibrato in order to be heard. When timbre and volume are used to bring the second formants of vowels closer together, the vowels stay intelligible but match the timbre of other vowels more consistently. Adjusting vowels, while controlling dynamics, is a powerful technique for creating unified ensemble regardless of the demands of pitch. It can also assist in maintaining voice quality during registration transitions. As such, it is an important tool for every organist choirmaster as well as the chorister.[36]

Because of their acoustic nature, open vowels are more susceptible to a wider vibrato pattern and a darker timbre. The acoustic spectrum of these open vowels makes it harder for singers to project their voices giving rise to the tendency to increase their volume in order to amplify the sound. Closed vowels, as demonstrated by Sten Ternström's study cited in Chapter 2, have a more shallow acoustic spectrum making them easier to focus and project. The acoustic nature of closed vowels offers a "cutting" quality that carries sound easily, eliminating the need to sing at loud volumes. Compare the two spectral slopes (figure 6) below for a visual understanding of this phenomenon.[37]

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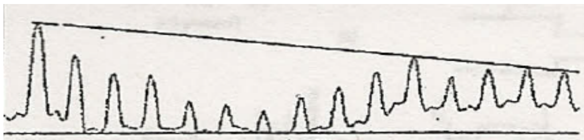
[36] Sundberg, Johan. *Vocal Tract Resonance in Professional Voice: The Science and Art of Clinical Care,* ed. Robert T. Sataloff, New York: Raven Press, Ltd., 1991, 60.

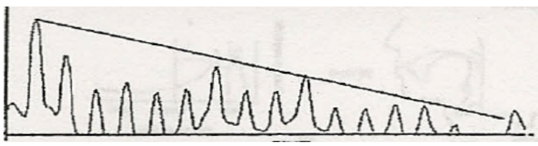
[37] Bebb, Gretchen. From lecture notes on resonance at the University of Houston, 2003.

Figure 6

Shallow Spectral Slope = a bright, closed vowel



Steep Spectral Slope = a dark, open vowel



Instruct your choristers to direct the vowel, whether open or closed, into the forward acoustic space of the oral cavity. In so doing, vowel integrity and dynamics can be better controlled and blended. Vibrato will be minimized and singers will be able to better balance themselves with their neighbors.

As previously discussed in Chapter 2, it is imperative that choir directors know which vowels to use when tuning their choral-organs. The closed vowels can "train" the more open vowels where to live in the acoustic landscape. The expression pedal of your choral-organ (dynamics) can assist in successfully negotiating registers, resonance and overall blend. Vowels can be used to train your choir's expression pedal but one must be able to successfully communicate those vowel sounds to a group of individuals in such a way that pronunciation is agreed upon by all. Take time to teach your choir the International Phonetic Alphabet symbols (see Table 2) associated with the most commonly used pure vowel sounds. Just as the organist practices the coordination of the hands and feet, so a choir must practice coordinating themselves between vowel and dynamics. Agreeing on vowels and making slight dynamic adjustments between vowels will bring about a dynamic and professional sound from your choristers. Consider playing games using the IPA symbols below written on small balls or beanbags. Start your rehearsals with physical warm-ups where the balls or beanbags are tossed between choristers as they make the vowel sound. Once your choristers are comfortable with the symbols, start to use the symbols along with dynamics shift from loud to soft while modifying between vowel sounds. This will help build laryngeal and respiratory muscle memory for application in anthems. For more fun ideas using the phonetic alphabet, explore *The Joy of Phonetics* and the phonetic pillow work of Louis Colaianni.[38]

Table 2

Introduction to IPA (Latin vowel examples)

[ɔ] Gloria	back, open AH
[ɑ] grave	central, open AH
[a] pasta (Italian ah)	front, closed AH
[ɛ] et	central, open EH
[e] per	front, closed EH
[ɪ] sit	central, closed IH
[i] sicut	front, closed EE
[o] prout	back, closed OH
[u] tu	back, closed OO

In terms of volume production, choir singers should hear their own voice in an adequate self-to-other ratio (SOR) over the rest of the choir. Singer's personal preferences will always differ in regards to SOR so it is vital that the organist-choirmaster tune the dynamic to a preferred collective output.[39] Simply put, you should not hear one voice over another. When a pipe organ is voiced, each rank of pipes is carefully balanced to its immediate neighbor and in relation to those pipes that speak softer and louder.

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[38] Colaianni, Louis. *The Joy of Phonetics*, Joy Press Kansas City, MO, 1994.

[39] Ternström, Sten. *Preferred self-to-other ratios in choir singing,* Acoustical Society of America, 1999. Document emailed personally from Dr. Ternström.

When the organist successfully builds a crescendo or decrescendo, it is done in such a way that the listeners are unable to discern that more pipes are asserted. Likewise, singers should create dynamic ensemble so as to increase and decrease energy in a manner that exhibits no discernible individual voices.

Voice scientist, Sten Ternström gave choristers (6 basses, 6 tenors, 6 altos, 5 sopranos, all members of Swedish choirs ranging in age from 19-62) the chance to determine their individual preference for SOR. Each participant was outfitted with head mounted microphones and asked to move closer or further away from a stationary microphone while singing either in unison (18 samples) or in a chord (18 samples) with a synthesized choir. The digital choir was projected from four speakers placed equidistant from the participant's average location. The participant would hear the digital choir begin the sung vowel and then the participant would join in as if to blend with the choir. While singing, the participant would move forwards and/or backwards until their perceived perfect SOR had been achieved. At that point, the participant would push a hand held signal button for five seconds all the while singing. As the participant would move, the synthesized choir would become louder or softer in correlation with the participant's movements. The average preferred SOR was +6.1 dB with the lowest self to other ratio (SOR) preference expressed by the basses and the highest the sopranos. There was no noticeable difference in SOR preference expressed by the participants when singing unison as compared to harmony (part of a chord). Ternström hypothesized the SOR preference expressed by the individual participants may very well be due to their usual location within a choir which would have direct impact on the amount of choir one usually hears and therefore a habitual preference may have been cultivated. However, the standard deviation in the SOR preferences expressed in this study varied only 2.2 dB. Ternström believes choral conductors could benefit from allowing singers to determine their SOR within the choir formation and arrangement.[40]

In an unpublished doctoral dissertation, J. K. Ford of Florida State University found that increased pharyngeal resonance through a classical approach to singing may not always be the ideal technique for a singer to use when serving as a member of a choir. In his study, the measurement of the singer's formant[41] (the fifth formant) was compared to a softer more blended choral approach. Dynamic differences between the two techniques ranged from -4.08 dB to -4.84 dB. Interestingly, a panel of six music faculty members was unable to identify the recordings by the presence or lack of presence of the singer's formant. Three groups of auditor participants (50 college music majors, 47 instrumental music majors, and 43 college students with no music training) showed overall preference for the less resonant (non classical singing), greatly reduced singer's formant style where the individual singers were blending within the ensemble. Results suggest that musical training had no effect on preferences.[42]

As an organist-choirmaster, one should be aware of masking within the choir and masking through accompaniment. Masking is the obscuring of one sound by another. Often a choir section is unable to tune because there is an individual singer that is louder than the rest of the group. Oftentimes such singers will attempt to be the loudest voice in a section or the choir as a whole. This is called the Lombardi effect. Steven Tonkinson

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[40] Ternström, S. *Preferred self-to-other ratios in choir singing.* Journal of the Acoustical Society of America, 105, 1999.

[41] Singing in the classical style typically results in a frequency range that gives optimal ring in the singer's voice. This ring is considered by voice scientists to be the signal of the fifth formant and is referred to in many publications as "the singer's formant." This is what allows singers to be heard over orchestras without the assistance of microphones.

[42] Ford, J. K. The Preference for Strong or Weak Singer's Formant Resonance in Choral Tone Quality. Unpublished Doctoral Dissertation, Florida St. Univ., Tallahassee. 1999.

explored its impact on choral singers in his DMA thesis at the University of Missouri-Kansas City. A singer attempting to sing too loud creates a competing sound which becomes a stumbling block for the rest of the choir. Such singers should be encouraged to sing softer. It is challenging for a singer to self-correct pitch if they cannot compare themselves to a reference tone or another singer. [43] More importantly, a singer is less likely to produce pitch accurately if the singer cannot hear a clear, harmonically rich reference tone. When singers are provided with a clear reference tone prior to producing their tone, the amount of error is reduced by 50%.[44] It is vital to the success of your choral-organ that each of your singers maintains a volume that enables every other singer to hear themselves and each other clearly.

Attempting to further understand an individual choir singer's contribution to the choral experience, Tonkinson recorded an ensemble of twenty-seven singers made up of hobby Church choir singers and college singers. The ensemble was recorded singing *The Star Spangled Banner* twice while listening to a choir and themselves singing through headphones. The singers were outfitted with harmonica holders for their microphones to ensure microphone placement and consistency throughout the recording. After the pre-test, prior to the second recording, the singers were informed of the Lombard effect and asked to resist succumbing to the Lombard effect by maintaining a consistent energy output (intensity). Results found that years of choral experience and voice lessons had little or no significance. There was an overall decrease of approximately 5 dB in the post-test suggesting that education and specific direction to correct for the Lombard effect was

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[43] Ternström, S. *Hearing myself with others: Sound levels in choral performance measured with separation of one's own voice from the rest of the choir*. Journal of Voice, 8 , 1994.
[44] Ternström, S., & Kalin, G. *Formant frequency adjustment in barbershop quartet singing.* International Congress on Acoustics, Madrid, September 2007, p. 1-6.

successful.[45]

As a side note: be mindful that the organ may also cause the choir collectively or individually to over-sing. Be cognizant not just of the dynamic energy of the pipe organ and the registration, but also how this might be either masking the choir or lacking the volume necessary to supply a reference tone. Singers with classical training will often be more operatic in their approach when they feel a need to be heard. This approach starts with more increased air pressure, often a tall, ringing, and wide open vowel, accompanied with much vibrato.

When balancing your choir's dynamic output, communicate your desired dynamic level to your choristers. Resist attempting to balance the choir to the softest or loudest voice. Rather, work with your choral-organ to find their foundation, their principal chorus volume upon which everything will be built. Chapter 4 contains ideas concerning vocalizing the choir through exercises that duly focus both vowel quality and intensity.

The Flute Harmonic of the French Cavaille-Coll organ is renowned for gradually increasing in volume as it is played up the scale. It also has the ability to be heard over full organ. Through amplification of the overtones created by the overblown double length pipe design, the sound seemingly gets louder to the listener. Your singers' resonance will have the same effect through amplification of high overtones by one or both of the vowel formants that cause the sound to become much brighter, which the listener may perceive as loudness. This can happen quite suddenly, depending on the frequency being sung and the vowel being used. If the formants are lowered so much that the higher harmonics in the sound are not amplified, the sound can become dark or

[45] Tonkinson, S. *The Lombard effect in choral singing*. Journal of Voice, 8 (1), 24-29. 1990.

covered, which will sound softer to the listener. Furthermore, an open vowel will sound different, depending on where the singer is in their range, because of the changing interaction of source harmonics and formant frequencies. If the formant frequencies are above but within approximately 100 Hz of a harmonic, the vocal tract will provide resonance for the vibrations from the vocal folds, resulting in a stronger sound. However, if the fundamental frequency and its overtones are above the first formant, or too far from either vowel formant, the projected sound will be weaker. As previously stated then, vowel modification can aid in producing dynamic variation.

A modification to the placement of the voice creates a change not just of perceived loudness but also timbre (color), since the relative strengths of the harmonics create the unique qualities of the voice (for example, certain pipes have stronger harmonics such as thirds, fifths that characterize the pipe quality). Therefore a change in timbre may indicate a problem with either formant (vowel) tuning or relative activity of the TA (thyro-arytenoid) and CT (crico-thyroid) muscles.

When working with reduced volume, your choristers may experience muscle coordination problems, vowel modification discrepancies, or a combination of both. The organist-choirmaster should not be intimidated when confronted with these vocal issues; voice teaching of any sort almost always involves a great deal of trial and error and often uses the "cold, warm, warmer, hot" method of helping singers find their optimum singing habits.[46] With an understanding of vowel acoustics and dynamics as it relates to negotiating registration shifts, as well as aural perception and sight, the organist-choirmaster is well-prepared to diagnose and help troubleshoot vocal issues concerning choristers.

[46] Titze, *Principles of Voice Production,* 83-84.

Chapter 4

TUTTI
Putting Together the Choral-Organ

Vocal exercises for choral ensembles are an important tool in developing discipline, process and approach. Unlike pieces from the choral repertoire, which may present multiple simultaneous difficulties, vocal exercises can be designed to “divide and conquer,” focusing on specific areas of vocal approach. For example, an exercise can be constructed to allow choristers to develop confidence in managing the passaggio on an advantageous vowel that facilitates success. The vocalise can help choristers develop agility without having to simultaneously cope with text articulation, or dynamic and musical implications. A graduated series of vocalises can be designed which will help even hobby singers extend their vocal production from the most basic to more advanced skills. Exercises can be constructed to address the specific challenges found in the repertoire your choir is preparing for performance or to address specific vocal production issues confronting your particular ensemble. When designing and using your exercises with your choristers, be creative, be specific, and be patient. Voice training is a process and it may take time to hear the fruits of your labor. Included herein are some exercises to help you get started. An audio recording of each vocalise is included on the inside of the back cover.

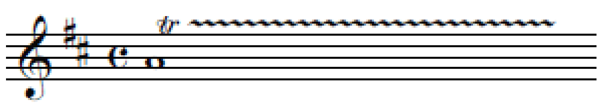
As you begin to explore your choral pipes, consider that there are many different ways of engaging the voice and the respiratory muscles. The voice we use to speak, laugh, cry, and shout with is the same voice we use to sing. A fun breath release activity that you can engage in with your choristers is laughing. Laughing can release the voice of tensions and allow the breath and resonators to be more active. During the laughing exercise below, encourage your choristers to have fun with their upper range extension. Because the laughing is fast-moving, the high notes are fleeting. Your singers may approach them with less inhibition than they do sustained high notes. Draw your choristers' attention to the freedom of production that is encouraged by the laughing.

The first group of exercises are meant to engage the breath and encourage a full body release of the sound. The primary goal of the following exercises is freedom of sound. Releasing the hold or squeeze on the respiratory and laryngeal muscles will advocate stable vocal fold vibration. Understand that released breath and freedom of sound is the foundation of any functional singing work. Many excellent resources are available which describe the fundamentals of breath management and may further aid the conductor in teaching this concept.[47]

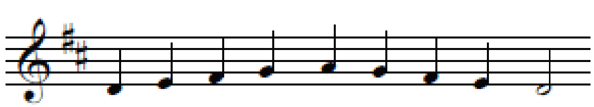
Exercises

1 a. *Releasing the breath and body*: encourage your choristers to allow themselves to giggle and laugh as they twist and shake out the arms, legs, hips, neck and spine.

1 b. *Releasing the breath*: **s**ing a sustained pitch on a lip trill (like the sound you make with a toy boat or car) or tongue roll (like the sound you make when rolling an 'r'. Instruct your choristers to allow the throat to be soft and released while trilling. [CD track 1]



1 c. *Releasing the breath*: **s**ing a five-note scale on a lip trill or tongue roll. Encourage your choristers not to articulate the changing pitches in their throats. The throat should be soft and released. [CD track 2]



[47] Conable, Barbara. *The Structures and Movement of Breathing: A Primer for Choirs and Choruses,* Chicago: GIA Publications, 2000; McCoy; Emmons and Chase.

Singing uses a variety of registers including chest, head, falsetto, whistle and mix. In choral singing, registration is generally head dominant in females, though chest and mix are often used and chest dominant in males, though falsetto and mix are often used. The laryngeal muscle responsible for higher, head voice singing is the crico-thyroid (CT) muscle and the laryngeal muscle responsible for lower, chest voice pitches is the thyro-arytenoid (TA) muscle. Register isolation work allows voice users to experience the sensations which relate to dominant TA (chest voice) or dominant CT (head voice) muscle activity. This awareness of sensations can bring about a more balanced vocal mechanism and, in turn greater flexibility during singing. Register isolation is part of Somatic Voicework™ *The LoVetri Method* vocal training developed by Jeannette LoVetri. This technique focuses on what the voice is doing, not just how the voice sounds. For more information on Somatic Voicework™ *The LoVetri Method* visit www.

If your choristers are aware of the correlation of cricothyroid muscle activity to head voice and thyroarytenoid muscle activity to chest voice and the sensations of each, they will quickly gain control over their registration choices. A brief explanation of this science behind the sound may prove extremely helpful for your choristers. For some singers, this kind of explanation might make sense and can help them develop their abilities. A simple explanation for your choristers might state:

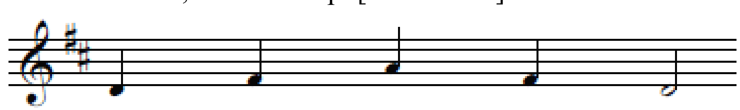
"There are two sets of muscles that are involved in changing pitch, one is more active when singing louder in the lower range of the voice and one is more active during softer, higher signing. These are sometimes labeled "heavy mechanism" and "light mechanism." A passaggio event or break in the voice happens when muscle activity is being transferred from one muscle group to the other. Abrupt transitions can cause phonation breaks or cracks in the voice. Blending or mixing the registers can prevent these cracks. If we use a light mechanism across these transition points, we can better blend our registers so it sounds as though we have one unified register throughout our range."

The exercises below are meant to allow singers to feel the difference between thyro-arytenoid muscle activity and crico-thyroid muscle activity so that they are able to engage or release the laryngeal muscles at will. The chest exercises should be done on low pitches with a heavier, louder sound quality. Resonance sensations for your choristers should be in the throat and upper chest cavities. Singers should keep their jaws dropped open to afford more pharyngeal space. The head voice exercises should be done on higher pitches with a very light and quiet sound quality. Resonance sensations for your choristers should be in the head and face.

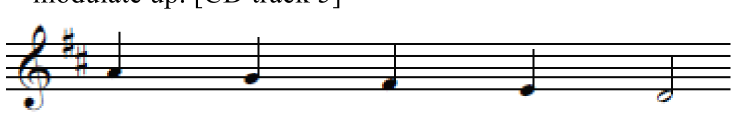
Exercises

2a *Isolating chest voice*: sing an ascending fifth on [a] or [o]; sung loudly. [CD track 3]

2b *Isolating chest voice*: sing an ascending, sustained triad on [ae]; sung loudly with the tongue out of the mouth; modulate up. [CD track 4]



2c *Isolating head voice*: sing a descending 5-note scale on [u] and [i]; sung very softly; modulate up. [CD track 5]



2d *Isolating head voice*: glide down a 5th on [ŋ]; sung very softly; modulate up. [CD track 6]

Below are a several etudes designed to teach your singers to manage muscle coordination during registration transitions. Each exercise contains specific vowel and consonant combinations with an explanation of the general function of the exercise, pitch levels and transpositions which are beneficial for the particular exercise. It's important that unison tuning work be done in a light, head dominant vocal mechanism. Using slightly softer dynamic will encourage head voice and prevent too much thyroarytenoid muscle activity (chest voice). Voice scientist Godfrey Arnold explains that louder singing engages the lower register, or heavy mechanism, more strongly.[48] Start your choir singing the exercises below at an easier, lighter dynamic level at first then carefully add volume as the muscle coordination and formant tuning becomes more habitual. Again, be patient and allow time for the technique to settle in the voices.

As discussed in a previous chapter, one of the causes of register breaks is a sudden change in mode of vocal production, going from chest voice (thyroarytenoid dominated) to head voice (cricothyroid dominated) production. In order to avoid the sudden shift, the singer must learn to mix and balance the cricothyroid muscle at a lower point in the tessitura; well before the shift point is reached. In so doing, you'll train your choristers to sing in the mechanism of the register they are approaching, thereby blending or mixing the registers. The goal of the exercises below is to train your singers to release the thyroarytenoid muscle as the pitch ascends. These vocalises may be especially effective on a forward vowel like [i] or humming on the consonant [n]. Ingo Titze suggests that a vowel with a low first formant frequency, such as [i], [e] or [u], as well as the [n] hum, can contribute to enlivened vocal tract acoustics, which encourages vocal

[48] Arnold, Godfrey. *Research Potentials in Voice Registers*, in Journal of Voice, April, 2004:150.

fold vibration. This type of vibration is precisely the sort found in a lighter registration.[49] The vowel sound may be preceded by a consonant such as one of the nasal consonants [m, n] or a voiced consonant such as [v], [z], or [b].

Begin the exercises below in unison on a single unified forward vowel on a mid-voice pitch so that some feeling of lighter registration is present in the sound. The pitch will vary depending on the skill level of the ensemble. A3 for men and A4 for women can be a good starting point just so it does not engage the "calling voice" described by Richard Miller, in which increased thyroarytenoid muscle tension and breath pressure are often applied by choristers, with accompanying unease.[50] It is above the passaggio for women, so it is not likely that women will engage their chest voice, or heavy mechanism, at the onset of the vocalise. By modulating these exercises down by half steps, your female choristers will experience a cross over of the first passaggio into a lower portion of the voice. This encourages them to learn how to gradually introduce increased thyroarytenoid contraction, rather than dropping suddenly into chest voice, and then to release the TA muscle contraction gradually as pitch ascends again.

Exercise 3b builds on 3a. This vocalise aids in the development of a lighter mechanism as the voice ascends. The added challenge in this vocalise is that the second half starts low in the voice and then proceeds higher. Singers will often start the bottom note in a louder, heavier mechanism, not anticipating the lighter mechanism on their way to the higher pitch. This exercise can teach them to anticipate a lighter mechanism when starting from lower pitches. The second part of the exercise should be sung using the same mechanism used in the first part of the exercise.

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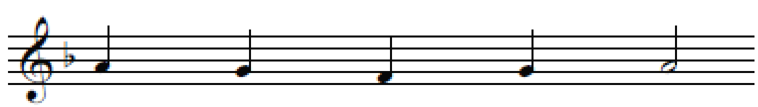
49 Titze, *Use of Low First Formant Vowels,* 41.
50 Miller, *Structure of Singing*, 116.

When your singers are ready, try exercise 3b using more open vowels such as [o] and [a]. Open vowels encourage more TA activity so it will be a challenge for your singers to maintain a balance in their registration and allow the vowel to resonate with forward focus. Taking time during your vocal exercises to re-communicate vowel shapes and color is part of the process of tuning your choral pipes. This is all part of voicing your choral-organ. Just as an organ pipe may require a little knock on the head during tuning, so too may your choral pipes need a little nudge during the tuning process.

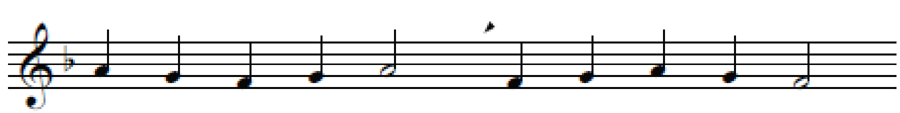
The exercises below will help your choristers smooth their transition from chest voice upward to middle voice and from head voice down. Modulating the exercises (by half-steps) up and down across though mid-voice will train the choir to produce a lighter mechanism as they approach their passaggio. Remember the role that volume control plays in the successful negation of shifts in registration. A brighter, forward vowel will further blend the registers. Do not be afraid to stop and re-tune as needed through verbal communication and/or clarification.

Exercises

3a *Blending the registers*: using [i], [e] or [u] (or combinations of these vowels). [CD track 7]



3b *Blending the registers*: This exercise builds on the 3a but descends lower in the voice where singers may intuitively add volume as they engage chest voice muscle activity. [CD track 8]



While your choristers are learning to master negotiating their registers, they may be responsive to these commonly used explanations of registration transition used by vocal pedagogues and choral directors:

- As you descend in pitch, your voice might pick up some extra weight. Try not to let it pick up too much, and as you go back up, let go of the weight, so that you return to the same weight you started with.

- Let the tone float gently down to the lower pitches, without forcing. (The idea here is to keep the singers from engaging the thyroarytenoid muscles too strongly or too soon.)

- Keep all of the pitches "behind your eyes." Don't let the sound fall down into your throat. (This corresponds to the vibrations many singers feel in their faces when singing in "head voice." Singers who do not experience these vibrations may not find this image helpful. Singers who are very logical may be resistant to this imagery, since the pitch is not produced anywhere but the throat. The conductor can explain that the vibrations of the vocal folds can be transferred through the tissues of the body, and often, vibrations felt in the face are a sign of a light mechanism. Singers should not receive the impression that they must feel vibrations in any specific location, however, since every singer is different.)

- Each pitch is a pearl on a string held vertically. Pitches near the bottom are represented by fairly large pearls, high pitches are small pearls, and for every note in between, the size of the pearl changes gradually. The size of the pearl corresponds to the muscle "weight" of the voice, so that the muscle activity on the top "pearl" is the same "size" both at the beginning and end of the exercise.

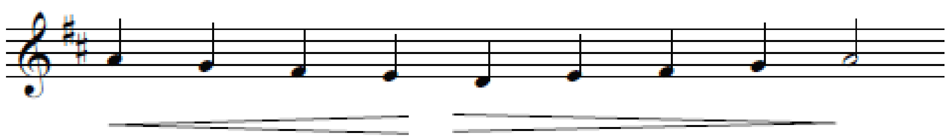
Work to develop imagery that works best for your choir and encourage your choristers to come up with their own as well. It can be useful for the singers to share their ideas and discoveries with each other.

Exercises 4a and 4b below will start to introduce more volume in the lower range of the voice. Once your choir has spent sufficient time sensationalizing head voice coming down the scale, try adding this next group of exercises to your vocalization regiment. Adding volume will make returning to the balanced production of the top note even more challenging. The singers should be encouraged to keep the higher pitches in a light mechanism as they return from the louder low range.

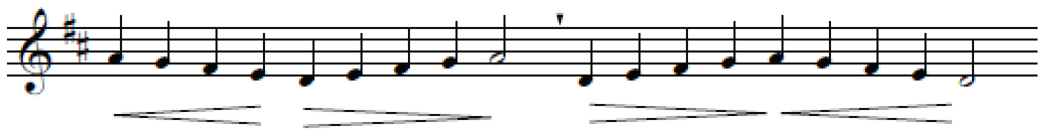
With these exercises, use open vowels such as [o] or [a] and a voiced consonant like [v] or [z] to keep the air flowing. Again, the volume should be balanced so that the weight of chest is not carried to the top.

Exercises

4a *Adding volume to chest*: use open vowels such as [o] or [a] and a voiced consonant like [v] or [z] to keep the air flowing. [CD track 9]

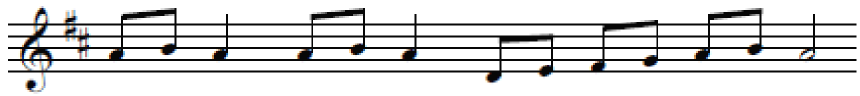


4b *Adding volume to chest*: use open vowels such as [o] or [a] and a voiced consonant like [v] or [z] to keep the air flowing. [CD track 10]



This is another vocalise that helps the chorister experience a lighter mechanism at the beginning then negotiate a drop into the lower range of the voice. Again, the real challenge here is to return to the higher pitches shifting back into the lighter mechanism. Begin this exercise in a light head voice mechanism (CT dominant) on the repeated opening inverted mordent then allow the voice to engage chest (TA dominant) fully, with volume. On the return to the upper notes at the end of the exercise, release TA and return to CT muscle activity.

Exercise 5 *Isolating the Registers*: use an [a] vowel in head voice, engage chest on the lowest pitch and return to head voice during the final ascent. [CD track 11]

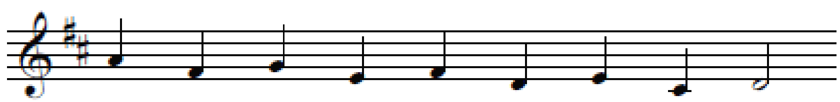


With these set of exercises, your choristers will go further in their ability to balance the muscle activity between registers. Each successive upward leap must lighten so that by the high note of the exercise, the crico-thyroid muscle has assumed much of the responsibility. The leap down in this vocalise will likely cause an increase in thyro-arytenoid contraction than was experienced with the stepwise motion of the previous exercises. If a singer engages TA with too much weight (volume), the return to CT can be challenging. In executing the downward leap, singers should try to coordinate CT and TA activity so that the stepwise motion does not require a dramatic muscular adjustment. They should try to experience less weight (TA) on each successive upward leap. This technique helps singers learn how to gradually increase the activity of the thyroarytenoid muscles rather than engaging them strongly at once, thus reducing the likelihood of an audible register break. This is especially important for polishing intonation in descending or ascending passages in the choral repertoire, especially those sections which cross a break.

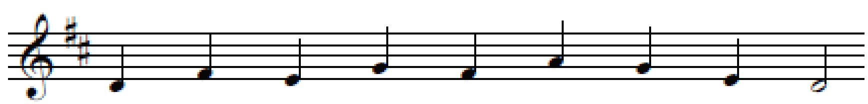
With Exercise 6a, start in the higher range and move down by half-steps. The forward [i] and [a] vowels may be useful starting points for this exercise, since they encourage the lighter mechanism to take hold. Pay particular attention to the jaw of the choristers making sure it is dropped and not chewing as they switch pitches. Re-instruct the choir to keep the focus of the vowel forward. Gradually, you can begin to use more open vowels on this exercise but with no preceding consonant. Focus your work on blending the registers gently as the exchange of activity between CT and TA takes place. The yodel effect of this exercise can be humorous as coordination of the muscles is happening. This rocking between registers is a sign of a free and flexible larynx and should be embraced by your choristers. Volume control will help smooth the exchange thereby achieving a better blend of the registers. Just remind your singers that by making collective changes in their vocal production, they create a uniform sound.

Exercises

6a *Rocking the larynx*: use an [i] or forward [a]; instruct your choristers to feel the gentle rocking of the larynx as the exchange between head and chest takes place. A released larynx may result in a slight yodel effect. [CD track 12]



6b *Rocking the larynx*: use an [i] or forward [a]; instruct your choristers to feel the gentle rocking of the larynx as the exchange between chest and head takes place. A released larynx may result in a slight yodel effect. [CD track 13]

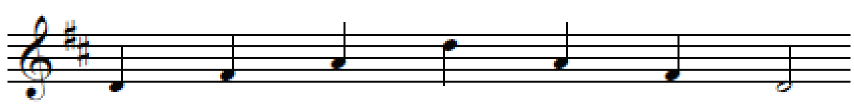


The next series of exercises are designed to use closed vowels to "train" the more open vowels with regards to forward focus.   While we've been doing that all along, these exercises are specific to formant tuning in the vocal tract. Forward vowels like [i] live at the front of the vocal tract because of the high forward tongue. The [i] vowel, therefore has a low first formant and can be used to "tune" open, back vowels such as [o] and [a]. Forward vowels allow singers to experience the sensations of forward resonance.

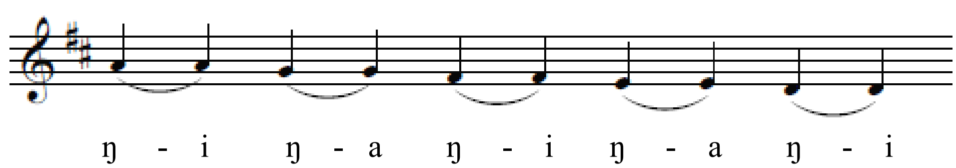
In Exercise 7a, encourage your singers to have fun creating tiny, mouse-like sounds. The vowel should remain very closed on the way up the scale. The sound should resemble Mickey Mouse. Exercise 7b uses the [ŋ] consonant as a pendulum between closed [i] and open [a]. The purpose of the exercise is to teach you singers to maintain the forward, head ring of the [ŋ] and [i] across both vowel sounds. Exercise 7c builds off of 7b in that the [i] vowel acts again as a guide for open [a]. This exercise also combines registration and resonance to help balance the sound from bottom to top. The low chest voice pitch is given a forward, head voice vowel and the higher head voice pitch is given an open, back vowel. This is a wonderful exercise for muscle coordination and tuning. The final exercise in this series, 7d, requires the singers to maintain the forward placement of the [i] vowel across the series of cardinal vowels. Encourage your choristers to make small adjustments along the way so that vocal tract tuning and muscle coordination are working together to achieve a unified ensemble.

Exercise

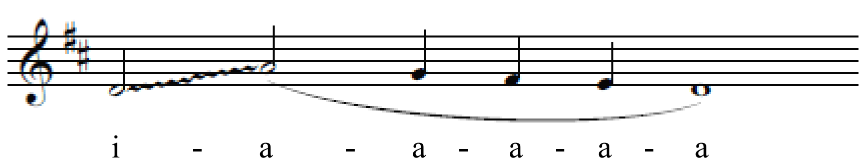
7a *Tuning the vowels/Training the space*: use [mi]; encourage your choristers to create a very Mickey Mouse-like voice, keeping the space closed as they ascend. [CD track 14]



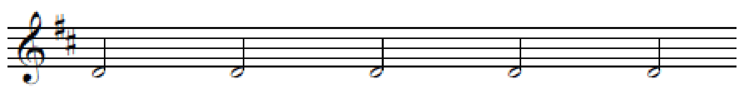
7b *Tuning the vowels/Training the space*: release the [ŋ] to the vowel by simply dropping the arch of the tongue. Instruct your choristers to keep the [a] vowel focused forward like the [i]. [CD track 15]



7c *Tuning the vowels/Training the space*: In a light mechanism, change the vowel at the point of the leap. Encourage your choristers to maintain the forward focus of the [i] as they switch to the [a]. [CD track 16]



7d *Tuning the vowels/Training the space*: Encourage your choristers to maintain the forward focus of the [i] vowel across the series of cardinal vowels. [CD track 17]



As your choir begins to produce a more unified choral tone, start introducing them to canons. Singing canons in unison is perfect preparation for homophonic and polyphonic choral pieces. As a point of departure, select a hymn or song that is scheduled for an upcoming service and instruct the choir to sing the hymn in canon with a monosyllabic approach using [mi] or [nu]. There is no right or wrong with the entrance of canonic voices; however, you can deliberately choose little or more dissonance in your canon exploration. Take time to nuance while shaping choral sound.

The choirmaster influences singing technique, vowel formation, manner of phrasing, aspects of musical direction, articulation, and so on. It is the organist-choirmaster's responsibility to listen to the choral sound, assess the sound, and then fine-tune the choral-pipes through a series of exercises intended to offer a systematic approach to building your choral sound. Choirmasters should be encouraged to write their personal exercises to explore and search for timbre and sonorities they want to instill in the vocal pipes of the choir. The exercises described herein are meant to help get you started in your exploration of the choral-organ. With them, you should be able to strengthen your choral singers' approach in the areas of breath, registration, dynamics, and resonance.

Conclusion

The tradition of organist-choirmaster has a rich and lasting history. Organ and choral music of the Western world has slowly evolved from the earliest intonations chanted by the Church. On this foundation rests both sacred and secular music of Western civilization. It was the church organist who composed, taught, directed and accompanied groups of singers and soloists in service music and anthems for the church.

In Europe, most especially England, there continues to be a healthy choral tradition fed by the many number of choir schools. The organist-choirmasters have most likely been brought up in this tradition as young choristers who go on to study organ at University to become an organ scholar/apprentice with the hope of securing their own post as organist-choirmaster. In America, the ladder to the position of organist-choirmaster looks a bit different. One can pursue their degree in organ, secure an upper level degree, and apply for the post of organist-choirmaster.

Both in Europe and America, as part of their training, typically an organist will at some point have participated in a semester or two of choral ensemble and/or received a semester of applied voice study. It is possible, however to have reached the post of organist-choirmaster without ever having been exposed to the art of singing nor having learned how to communicate with singers. Trained organists are exposed to the mechanics of the pipe organ, the science of the sound being created, and how to negotiate the instrument in order to create the desired output. Organists, however have limited exposure to the physiology of the voice, the acoustics of vowels or how to manipulate a vocal tone. The discipline incorporated into the training of organist-choirmasters is deficient, if not barren in the area of vocal pedagogy. In most cases, organists are left ill equipped in terms of vocabulary and tools to begin instructing and constructing an ensemble of singers.

Relating the pipe organ to the voice, organist-choirmasters can accomplish a high degree of success in working with their choristers. We have seen how the two instruments are similar, we have related the mechanics of one to the workings of the other, we have tuned the pipes and exercised the reeds and are ready to embark on a new approach to working with our choristers. Ease into your application of this found knowledge. Remember that each singer has their own fingerprint, each is unique. Give your choristers time to develop individually while they work to find their choral blend. Define the goal of this work with your singers. We do this in order to create a stream of expression by which the listener is captivated and their soul is nourished. Make this goal a priority of your weekly practice. Be patient with your singers during exercises. Vocalizing is likely not the reason they participate in your choir, but vocal exercises are the only way to excel as an ensemble. Make the exercises become elemental and fascinating to mind and body, like meditation. Create a safe singing environment where experimentation is encouraged and respected.

Start simply and work your way into more complex tasks. In the opinion of Wilhelm Ehmann, developing a good choral tone begins with unison singing. "The most basic and vital aspects of the choral art are to be learned from unison singing....Unison singing is the preparatory school for polyphonic singing and requires the ultimate in terms of freedom and relaxation."[51] Sing in unison until your choral-organ is well in tune then begin to explore other colors and registrations.

Singing is so imbedded in the history of church music and so elemental in our role as organist-choirmasters. We are all natural singers. The potential for great singing slumbers in us all. The human voice is the most adjustable musical instrument in existence. Enjoy exploring the voices of your choral-organ. Whatever the quality of the instrument, if it expresses the music and the words, you will have interested listeners.

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[51] Ehmann W. *Choral Directing.* Wiebe G, trans. Minneapolis, Minn: Augsburg Publishing House; 1968:152.

Appendix A
Summary of Research

In his landmark text The Science of the Singing Voice, Johan Sundberg states: The reader has probably already observed that most of the questions regarding choral singing were not mentioned in this chapter. This is not surprising, because of the scarcity of choral research in the past, as mentioned. Here we can only mention some of the questions that seem possible not only to pose but also to answer... Evidently, choral singing offers a large field for scientific research, full of questions that can both be formulated and answered. Let us hope that it will attract the attention of a greater number of researchers in the future than in the past.[57]

In the article "Physical and Acoustic Factors that Interact with the Singer to Produce Choral Sound," Sten Ternström also points to the need for research in this area: All this musical activity notwithstanding [the fact that choral singing is second only to music listening as far as being the musical activity involving the most people worldwide], choir singing has attracted little attention from acousticians...There seem to be few instances of research done specifically on the acoustics of choir singing.[58]

In the article "An Acoustical Study of Individual Voices in Choral Blend," Allen Goodwin also laments the fact that there is virtually no empirical data available to researchers and choral directors on how certain vocal factors affect choral blend.[59]

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[57] Sundberg, *The Science of the Singing Voice*, 144-5.
[58]Ternström, *Physical and Acoustic Factors that Interact with the Singer to Produce Choral Sound*, 129.
[59] Goodwin, Allen W. *An Acoustical Study of Individual Voices in Choral Blend*, Journal of Research in Singing 13, 1989: 25.

Hunt, W.A. "Spectrographic Analysis of the Acoustical Properties of Selected Vowels in Choral Sound." Ph.D. Diss., North Texas State University, 1970.

This study seems to have been the first to have analyzed a choir's sound from the acoustical perspective and, as such, represented truly groundbreaking research. Hunt sets out to put an objective and quantifiable face on the very subjective acoustical concept of choral blend. The study had a multi-faceted purpose that included:

1) a grouping of recordings of certain vowel sounds into well-blended and poorly-blended categories;

2) a spectrographic analysis of distinguishing acoustic properties leading to this categorization;

3) a listing of the qualities and properties of the two categories;

4) a set of suggestions and implications for the teaching of choral singing.

The author began with the premise that vocal timbre should not be altered in order to achieve better blend. He thus worked only with vowel sounds stating that vowel unity seems to be accepted as the most important factor in vocal blend.

As data for the listening group, he recorded 216 examples of choral sound, 72 each from junior high school choirs, senior high school choirs and college choirs. Each choir sang a C major scale on the vowels [i], [a] and [ɛ], first with the male singers only, second, with females and last as a mixed choir. In listening to the taped examples, the jury was asked to 1) identify the vowel sound being sung; and 2) rate the blending quality of the ensemble as Good, Acceptable or Poor. Judges were fairly consistent in their opinions on blending quality. The female voices rated far higher in their blending quality than did the male voices which scored only 15% overall in the 'good' category. The judges were almost always unanimous in their correct identification of the vowel sound being sung.

Spectrograms were then made from each of the taped examples and each spectrogram was categorized and labeled according to the mean rating of the jury's opinions on blending qualities. The salient acoustic features of the spectrograms were identified and correlations between the jury's judgments of sound examples and their corresponding spectrograms were drafted. The investigator found that the spectrographic traits of the examples that were deemed to have 'good' blend included tonal clarity – all sound that was emanating from the ensemble fit into the natural harmonic series of the pitch being sung. There was no extra 'acoustic noise' between overtones causing sound that did not fit into the natural frequency bands for that particular sung sound. On the other hand, spectrographic traits of sound examples associated with 'poor' blend were found to have much more acoustic energy between the overtones of the sung sound's natural harmonic series. The horizontal frequency bands were not as clear and showed definite acoustical confusion. Acoustical factors that were not in tune with the fundamental frequency were quite apparent in the analyses. The junior high group received the most 'good' ratings from the judges (although the groups were fairly close statistically), as did the women singing alone across all age groups. The vowels [i] and [a] were most often rated as having a 'good' blending quality while [ɛ] was seldom found in the 'good' category. Hunt draws three general conclusions from his study:

1) unity of vowel sound is of utmost importance in the attainment of ensemble blend;
2) vowel unity is achieved through the tuning of vowel formant frequencies;
3) good vocal blend is dependent on all of an ensemble's acoustic energy falling into the frequency bands of the fundamental frequency's natural harmonic series.

Bolster, Stephen C. "The Fixed Formant Theory and Its Implications for Choral Blend and Choral Diction." The Choral Journal 23,6 (1983): 27-33.

Bolster begins this seminal article with a good general account of vocal acoustics which is useful for the choral conductor and in fact anyone interested in the study of vocal acoustics. He is principally preoccupied with the fact that all voices are governed by the same laws of nature when it comes to resonance and that ensembles must work as efficiently as possible within these laws if they are to enjoy acoustic success. This article includes a very complete and useful account of the properties of vowels and their intricacies according to the very specific spectral pattern each exhibits. As in many other published works, he discusses the manner in which the intelligibility of each vowel is surmised from the frequency of its first two formants. He subscribes to the view that the fact that vowels maintain constant formant frequencies regardless of the fundamental frequency signifies that vowels have pitch and the specific pitch of vowels must be dealt with in any form of singing, but particularly in choral singing. The author also launches into the subject of vowel modification, but does so slightly differently than others. He presents some important acoustical peculiarities among each of the sections of a mixed chorus. For instance, because the fundamental frequency sung by sopranos is often above the frequency of the first formant, they are unable to properly sing the vowel. “Instead, they must modify the vowel to create an illusion of the vowel intended by raising the lowest formant frequency to match the fundamental”.[60] According to Bolster, the sopranos in any choir have very few vowels at their disposal to sing a proper sound above the pitch F5. According to the author, the aim of vowel modification in choral singing is to ensure that all sections are singing at optimum resonance at all times.

He also discusses the fact that men and women modify vowels differently and that men must open their vowel space at the bottom of their range and close the same as they approach their upper voice (d#4-f#4). Women on the other hand must open their vowel space at the top of their range and progressively close it in descending the scale if they are to maintain optimum resonance by matching formant frequencies. The different sections of an ensemble will essentially need to be pronouncing words in a slightly different fashion at the same time if beautiful, full choral sound is to be the aim. In terms of vocal blend, he strongly supports vowel unification as the most important issue in choral blend. However, in his view, singers do not all need to sing exactly the same vowel for the tone to be unified, but must sing the illusion of the same vowel according to the vowel modification sections must undergo to stay within optimum resonance at the pitches they are required to sing.

He also vehemently opposes having the good singers in an ensemble undersing in order to not stick out from the rest of the choir’s sound. He maintains that it is unhealthy to ask choristers to remove singer’s formant energy from their voices if it comes to them naturally. Instead he advocates teaching all the singers of an ensemble to sing with good glottal closure and optimal resonance so that by all producing similar vocal energy and timbre, a blended but energized sound might result.

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[60] Bolster, Stephen C. *The Fixed Formant Theory and Its Implications for Choral Blend and Choral Diction*, The Choral Journal 23, 1983: 28.

Ternström, Sten, Johan Sundberg and Anders Colldén. "Articulatory $f0$ Perturbations and Auditory Feedback." (Journal of Speech and Hearing Research 31 (June, 1988), 187-192.)

The aim of this study was to determine if there was validity to the theory of the intrinsic pitch of vowels in choral singing and if specific information could be collected on the causes of this phenomenon. Another aspect of the experiment was to calculate the extent to which a masking noise introduced through headphones (making it difficult for the subject to hear his/her own voice) affected a singer's ability to deal with the 'intrinsic pitch' phenomenon. Singers were asked to sing twelve different vowel pairs in legato fashion on the same note. The investigators studied the effects on the fundamental frequency of these changes in vowel and articulation. They identified two different manners of effecting vowel changes during the experiment which they labeled as $f0$ transient and bimodality. $f0$ transient was the label used for instances in which the subject showed a temporary change of pitch at the moment of vowel transition, but then recovered fairly quickly to the pitch of the original vowel. $f0$ bimodality was used as the label for pitch excursions that were less temporary and continued into the singing of the entire duration of the second vowel, i.e. the second vowel of the series was noticeably higher or lower than the first vowel in its entirety. The study showed that transitions falling into the $f0$ transient category were more common than those considered bimodal (55% to 40% respectively).

Compilation of data showed that the two vowels [i] and [y] had the highest average fundamental frequencies when paired with another vowel. The largest deviations in $f0$ which created a bimodal effect quite consistently occurred on transitions from [i] to [a] and [i] to [ɛ]. When averaged out, these transitions were responsible for a 34.6 and 22.3 cent loss in pitch respectively.

Another facet of these experiments helped to clarify whether the frequency changes were caused by perceptual factors (e.g. the vowel sounds different therefore vocal changes need to be made to properly pronounce that vowel) or by articulatory factors (e.g. jaw dropping causes change in vibration). The investigators used sound masking to determine whether or not the changes in pitch had a perceptual basis, reasoning that if the changes were caused by articulatory movements, they should be more extreme and occur more often when the singers' own voice is masked during experiments. This was indeed found to be the case with all subjects but one exhibiting greater deviations in pitch when their auditory feedback was masked.

The investigators also found that vowel changes necessitating a large vertical movement of the tongue caused considerable deviations. They found this to be in keeping with previous studies advancing the “tongue-pull” hypothesis which supposes that the raising of the tongue for the high vowels ([i], [y]) causes a longitudinal stretching of the vocal cords bringing with it a rise in fundamental frequency.

Ternström, Sten and Johan Sundberg. "Intonation Precision of Choir Singers." J. Acoust. Soc. Am. 84, 1 (1988): 59-69.

This study tested two major hypotheses from the outset:

1) how does the intensity of sound, measured in SPL (Sound Pressure Level), experienced by singers from within a choir affect their ability to sing in tune in a choral situation?

2) do changes in the spectral make-up of the sound coming from a choir which surrounds choristers affect their ability to sing in tune?

The average SPL reference experienced by most choral singers within a choral rehearsal or concert was surmised by placing an experimenter wearing a pair of calibrated binaural microphones in different positions among choir members during a rehearsal. The reference refers to the sound a singer hears coming from the entire choir around him. The feedback was also measured and factored into the total sound intensity experienced by a singer within a choir. The feedback is the sound that a chorister hears coming from his or her own voice from within the choral context. SPL was averaged from among the data collected. It was found that both of these values varied rather significantly (40 dB). During the experiment, a reference tone was fed to the subjects via headphones at six different amplitudes within the noted 40 decibel range. While the reference tone was sounded, subjects were to sing their own sound into an SPL meter at approximately 90 decibels which was then mixed in with the reference tone in the headphones they were wearing. They were to match the pitch and vowel of the reference tone.

Investigators found that subjects had little difficulty in accurately matching $f0$ values when the reference tone was relatively soft. However, when the stimulus tone's intensity was increased, singers began to sing below the target pitch at a rate of 1.9 cents per decibel (a semi-tone is comprised of 100 cents).

This occurred in eight out of the nine subjects. It was noted that singers had more difficulty with this on the vowel [u] than [a]. Investigators then turned to certain spectral properties that might affect group intonation. They tested whether stimulus tones of harmonic intervals that contained common partials were easier for singers to tune to than intervals with no common partials (stimulus tones were artificially synthesized and had no high partials). They also tested whether or not the absence of vibrato in the stimulus tone might aid choristers in matching pitch more successfully. It was found that adding the first common partial to a simple stimulus tone was helpful for choristers who were attempting to tune a 5th above that tone. This procedure was even more helpful when singers were attempting to tune a major 3rd to the stimulus tone. Adding upper partials seemed a very successful aid in helping singers tune more accurately to the given tone as did removing its vibrato.

Ternström, Sten and Johan Sundberg. "Formant Frequencies of Choir Singers." J. Acoust. Soc. Am. 86,2 (1989): 517-522.

Ternström and Sundberg studied the formant habits of eight bass choral singers in both speaking and singing modes. Basses were chosen for the study because their lower fundamental frequencies generate more closely spaced overtones, making formant peaks easier to identify. Spectrograms were made of all the recordings and formant frequencies for formants one through four were collected and plotted for analysis. Results showed that the singers tended to naturally alter their formant frequencies when moving from speech to singing. In general, the second formant tended to be lower, especially for the front vowels [i] and [æ]. Although they found several differences between speaking and singing modes, the investigators were able to deduce, with the help of previous studies, that the first two formant frequencies were close to identical for singers whether in the solo or choral singing mode. It was also found that the frequencies of formants 3 and 4 were lower in professional singers than in non-trained singers. These upper formants tended to behave in a similar fashion for non-trained choral singers whether they were speaking or singing. Professional singers, on the other hand, tended to have much more pronounced singer's formant in the singing mode. The researchers also noted a definite clustering of the 3rd to 5th formants in singing mode, particularly in the professional singers. Further, they determined that the deviations of formant frequencies among the eight subjects were greater in speech than they were in singing where they enjoyed greater resonance homogeneity, i.e. when they sang together, the subjects assumed a "choral dialect" of sorts. Subjects were found to adjust their formant frequencies, especially for the lower formants, when singing with their colleagues, apparently with an aim to achieve vowel purity and blend.

Goodwin, Allen W. "An Acoustical Study of Individual Voices in Choral Blend." Journal of Research in Singing and Applied Vocal Pedagogy 13, 1 (1989): 25-34.

The main purpose of this study was to analyze the spectrums of both solo singing and unison choral singing in order to determine what acoustical differences exist between blended choral singing and solo singing. After an excellent summary of the important concepts of vocal acoustics, Goodwin launches into the experiment which involved thirty experienced choral sopranos. First, each soprano sang a sustained tone as she normally would in a solo context. She was then asked to sing the same sustained tone and vowel, but this time to attempt to blend with the sound of the pre-recorded ensemble she was hearing via headphones. Differences in the two modes of singing were quite substantial with subjects using less and more irregular vibrato when attempting to blend. In spectrograms taken during the two portions of experiments, there was a definite paucity of spectral energy above the first formant frequency in the samples related to blended sound. This Goodwin explains by stating that choral singers forego producing upper spectrum energy in their sound in order to provide the listener with fewer aural cues to separately identify their particular voice. He also identifies this technique as being effective in reducing the overall intensity of a sound, as a sound with more partials, though it may be at the same physical intensity as a sound with fewer partials, will be perceived as louder by the ear. It was also discovered that formant frequencies remained basically the same for the two modes of singing. Due to this consistency, the author concludes that vowel modification for blending purposes has more to do with varying the proportionate strengths of the formants than altering the actual formant frequencies. Not surprisingly, the overall intensity of singing levels dropped noticeably in the choral context as did the level of vibrato used.

Ternström, Sten. "Physical and Acoustic Factors that Interact with the Singer to Produce Choral Sound." Journal of Voice 5, 2 (1991): 128-143.

This is a very important and comprehensive article covering many of the central questions relating to choral acoustics. The author begins by saying that next to music listening, choral singing is the musical activity that engages the greatest number of people worldwide. Because of this fact, he finds it deserving of far more research than has been carried out in the past. Ternström first deals with the issue of a chorister's personal loudness when singing in an ensemble situation, acknowledging that it can be neither too loud, lest it become individually audible outside of the ensemble, nor too soft as the chorister will be unable to hear herself from within the choral context and therefore probably not sing to the best of her abilities. He examined the ideal 'self to others' ratio for choral singing and found that choristers performed best when they could hear the reference (the rest of the choir) and the feedback (their own voice) to fairly equal extents. As soon as the reference became more than 5 decibels louder than the feedback, choristers' intonation errors began to register at greater than 20 cents. Intonation errors occurred more gradually when the singers' own voices were louder than the reference. He also tested if certain vowels were more likely to adversely affect group intonation than others. It was found that vowel transitions requiring large tongue and jaw movements such as [i] to [a] or [i] to [ɛ] caused the $f0$ to drop with the tongue and jaw for lower vowels [a, ɛ], or to rise for the higher vowels [i, y]. This he found fully supported the theory of the intrinsic pitch of vowels. The worst vowel combination attempted in the study was [i] to [y] which caused a loss in pitch on the order of 35 cents. The author continues by studying the effects of timbre and homogeneity of resonance on ensemble singing. Matching of formant frequencies among singers is advanced as a method of increasing vowel intelligibility and improving vocal blend. In experiments, he found that a more neutral pronunciation of vowels was used than in solo singing. This was determined by the distance between the first two formants as well as their strengths which were closer together and slightly weaker respectively in choral singing. It was thought that this acoustic neutrality probably enables singers to blend fairly successfully. Ternström attests to the fact that he has rarely seen evidence of a singer's formant in the spectra of choral singers in the choral context and that solo and choral singing seem to require different training.

Next the author considers the effect that room acoustics has on choral singing. It was discovered that choristers tended to sing louder in absorbent rooms to compensate for the decrease in the resonance feedback of the room. Singers also regularly raised the frequency of their lower three formants in an attempt to hear the type of sound to which they were accustomed. Having choristers sing with their backs against a hard wall was found to increase the ensemble's intensity by 6 decibels without changing any aspect of their singing. The author coins a new term when mentioning the acoustical phenomenon of the chorus effect, i.e. the summing of many slightly asynchronous vocal signals coming together to produce one blended ensemble sound. He finds this sound property so important to choral singing that he calls it the chorusness of the choral sound. This acoustical phenomenon was seen as an amalgamation of the phase incoherencies of several aspects of the choristers' sound (pitch, vowel, vibrato) combined with the sound of the room to "magically dissociate the sound from its sources and endow it with an independent, almost ethereal existence of its own."[61]

It was found that the beating of partials caused by the flutter of independent voices was mostly responsible for the "chorusness" in a choir's sound.

This brings the author to the subject of group intonation. While it is understood that not all choristers will be singing exactly the same note at exactly the same phase in time, it is important that the averaged sound of the choir be perceived to be on the proper pitch. Ternström explains how it was possible in experiments for there to be an acceptable amount of scatter (individual, momentary deviation from target pitch) without the group's intonation being adversely affected. He found that scatter levels in the area of 10-20 cents were typical with choirs deemed to have acceptable intonation.

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[61] Ternström, *Physical and Acoustic Factors that Interact with the Singer to Produce Choral Sound*. Journal of Voice 5, 1991: 141.

Ternström, Sten. "Perceptual Evaluations of Voice Scatter in Unison Choir Sounds." Journal of Voice 7, 2 (1993): 129-135.

In this article, Ternström first launches into a lengthy explanation of the differences between vocal flutter and scatter. Flutter he describes as being quick fluctuations in fundamental frequency in an individual voice (vibrato fits into this definition). Scatter is defined as being the standard deviation in mean $f0$ when all of the voices are compared with each other. The main objectives of the study were to test two main hypotheses: 1) that pitch scatter is not aurally acceptable to the same degree for different $f0$ values (this was to determine the importance of this phenomenon for the various sections in a vocal ensemble); 2) that pitch scatter is not equally acceptable for different vowel sounds. Subjects in the experiment had the ability to independently electronically synthesize the amount of scatter with which they could play back the tone and come to a judgment of what type of deviation they 'preferred' and what they were willing to 'tolerate.' It was determined that voice category and vowel had only a limited effect on the subjects' opinions. For example, while the amount of scatter judged acceptable for the vowel [u] received the highest rating for bass, tenor and alto voices, it was deemed the least acceptable vowel for scatter in soprano voices. It was found, however, that in general pitch scatter was deemed acceptable if it was confined to deviations of 0 to 5 cents, and would be tolerated until it reached 15 cents.

Those opposed or indifferent to modification include many choral directors and some voice teachers. Pressed for the reasons behind their objections, they generally cite lack of blend and unclear diction. In an effort to promote the elusive "blend," directors sometimes subscribe to reducing their singers' sound to the level of the least resonant voice in the group.

Seeking intelligibility of the words and recognizing that an audience comprehends the words most often from the soprano section, choir directors frequently ask high voices for speech vowels. Not only is this difficult for sopranos but it also cannot give the correct and identifiable linguistic sound. Difficulties in the upper range of the soprano and tenor voices come about, especially in amateurs and young singers, because the gradual thinning and elongation of the vocal folds increase with ascending pitches. To cope with this requires extra energy in the breath and great skill, which amateurs and young singers do not possess until trained. Speech recognition, which all directors desire, "is dependent upon the changing shapes of the filtering resonator tracts above the larynx. . . . Attempting to exercise *direct laryngeal controls* causes the articulatory mechanism to malfunction" (emphasis added). Consider seriously the following basic truth: high notes and very dynamically intense notes are musical events, not text events—musically effective, not textually effective. Asking for a text event on high or loud notes may produce an uncontrolled and unattractive result.

As for intelligibility of vowels in particular, research done on perceptibility tells us that, when each voice reaches the pitches near its high passaggio, the human ear can no longer tell the difference between that voice singing one front vowel or another, one back vowel or another. Why sing a vowel that is incompatible with the sung pitch, thus more difficult to execute, if the listener cannot even tell that you are singing it?

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